ISSN 0713-9330

AIR QUALITY

NORTHWESTERN ONTARIO

Annual Report, 1987

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Ontario Ministry of the Environment

December 1988

c Queen's Printer for Ontario, 1988

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SUMMARY

This report presents results of the Ministry's air quality assessment program for 1987 in northwestern Ontario. It includes data from 10 communities where long-term monitoring is conducted, plus summaries of special surveys in Thunder Bay.

ATIKOKAN

The Ministry and Ontario Hydro continued their monitoring programs around the 200-megawatt thermal generating station near Atikokan. During 1987, there were no exceedences of air quality objectives for sulphur dioxide, nitrogen dioxide or ozone.

Near the Pluswood Manufacturing particleboard plant, dustfall complied with the provincial objective.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. All vegetable samples from residential gardens met guidelines for arsenic and mercury.

During the growing season (May to September), hourly average sulphur dioxide exceeded the acceptable limit 23 times, compared with 28 occurrences in 1986, and 61 in 1985. There was no visible vegetation injury caused by sulphur dioxide either on or off company property.

DRYDEN

According to sulphation measurements, average odour levels near a secondary treatment system (lagoon) for kraft pulp mill effluent were low throughout the year. There was no significant off-property fallout of foam from the lagoon.

Levels of suspended particulate matter in the town centre were satisfactory.

Odour levels in central Dryden continued the excellent trend of improvement recorded in recent years. The Ontario TRS guideline was not exceeded at any time in 1987.

FORT FRANCES

There was no off-property vegetation damage caused by air pollution around the local kraft pulp mill or near the mill's secondary treatment basin (lagoon).

While lower than the 1986 level, average dustfall still exceeded Ministry objectives. Average suspended particulate concentrations were slightly above the Ontario limit near the kraft mill, and were satisfactory at a more distant site. Improved emission controls on the mill's recovery boiler are expected to reduce particulate fallout by 1989.

Odour levels continued their recent worsening trend; the number of exceedences of the TRS guideline near the mill was 87 in 1985, 300 in 1986, and 450 in 1987. The emission source thought responsible for many of the high readings in 1986 and 1987 will be controlled in 1988. Other odour controls are being considered. This issue will be addressed in a new Control Order now under negotiation.

KENORA

Some exceedences of the dustfall objective were recorded at one of the four monitoring sites near a sulphite pulp mill. The current Control Order on the mill requires compliance with Ontario regulations for particulate emissions by mid-1988.

MARATHON

Odour levels near a kraft pulp mill improved somewhat from 1986 to 1987, but there were still 93 exceedences of the TRS guideline.

Near the mill's wood-chip storage area, fallout of wood fines did not appear to cause a significant nuisance in 1987. There was general compliance with dustfall objectives.

An air emission inventory will be carried out by the mill in 1989. Sources not in compliance will be addressed in a new Control Order.

RED ROCK

Emissions from power boilers at the local kraft pulp mill caused occasional exceedences of the Ministry's dustfall objectives in 1987. Improved abatement of such discharges will be required in a new Control Order for 1989.

Periodic shutdown of the pulp mill's lime kiln resulted in fairly frequent exceedences of the provincial TRS guideline. It is expected that work in progress under the current Control Order will achieve compliance with the guideline by the end of 1988.

TERRACE BAY

There was a decline in air quality in Terrace Bay in 1987; the number of TRS guideline exceedences rose from 72 in 1986 to 121 in 1987. This poor record was ascribed mainly to operating problems with the lime kiln at the kraft pulp mill nearby. The current Control Order requires TRS guideline compliance by mid-1989.

THUNDER BAY

Average dustfall in Thunder Bay in 1987 was within the acceptable range at all but one of the 10 monitoring sites. Particulate emissions from a local pulp mill caused dustfall at one site to slightly exceed the Ontario objective.

Suspended particulate matter met the annual provincial objective at all six sites monitored. Soiling index levels were also acceptable at all times during the year.

Carbon monoxide, nitrogen dioxide, ozone and sulphur dioxide consistently met Ministry objectives in 1987. Temporary operating irregularities at a kraft pulp mill resulted in a few exceedences of the TRS guideline during June.

RÉSUMÉ

Le présent rapport donne les résultats, pour l'année 1987, du programme d'évaluation de la qualité de l'air mené par le ministère de l'Environnement dans le nord-ouest de l'Ontario. Il comprend les données provenant de dix localités faisant l objet d'une surveillance à long terme et les sommaires d'études spéciales effectuées à Thunder Bay.

ATIKOKAN

Le Ministère et Ontario Hydro ont continué, en 1987, à prélever des échantillons près de la centrale de 200 mégawatts d'Atikokan. Les limites pour l'ozone, le dioxyde d'azote et l'anhydride sulfureux n'ont pas été dépassées.

Par ailleurs, les retombées de poussières aux environs de l'usine de fabrication de panneaux de particules Pluswood étaient conformes aux critères provinciaux.

BALMERTOWN

Les concentrations d'arsenic étaient encore élevées dans la végétation située sur les terrains de la compagnie près de deux mines d'or, mais elles étaient presque normales dans la ville, avoisinante. Les concentrations de mercure et d'arsenic de tous les échantillons de végétation prélevés dans les jardins résidentiels respectaient les lignes directrices à l'égard de ces deux métaux.

On a mesuré, pendant la saison de végétation (de mai à septembre), 23 cas où la concentration moyenne d'anhydride sulfureux en une heure dépassait la limite maximale, comparativement à 28 cas en 1986 et à 61 en 1985. La végétation n'a pas été endommagée par les émissions d'anhydride sulfureux, tant sur le terrain de la compagnie qu'à l'extérieur.

DRYDEN

On a mesuré les odeurs dégagées par le bassin de traitement secondaire de l'usine de papier kraft à l'aide de la méthode de sulfatation. Les résultats indiquent des concentrations peu élevées au cours de l'année. Les retombées de mousse au-delà des limites de l'usine étaient très restreintes.

Par ailleurs, les concentrations de particules en suspension dans le centre-ville étaient acceptables.

À cet endroit, les odeurs continuent à baisser, confirmant ainsi la tendance amorcée il y a quelques années. En 1987, le seuil pour le soufre total réduit n'a jamais été dépassé.

FORT FRANCES

Ni la végétation hors du terrain de l'usine de papier kraft ni celle située près de son bassin de traitement secondaire n'ont été endommagées.

Par contre, les retombées moyennes de poussières, quoique inférieures à celles de 1986, étaient encore supérieures aux objectifs ministériels. Les concentrations de particules en suspension mesurées près de l'usine de papier kraft étaient légèrement plus élevées que le seuil fixé par le Ministère; un peu plus loin, elles étaient acceptables. On s'attend que, d'ici 1989, les émissions de particules produites par la chaudière de récupération diminuent, grâce à l'amélioration des mesures de dépollution.

Le seuil énoncé par le Ministère relativement au soufre total réduit a été dépassé à 450 reprises en 1987, comparativement à 87 en 1985 et à 300 en 1986, ce qui confirme la tendance à la hausse des odeurs nauséabondes amorcée il y a quelques années. En 1988, on imposera des mesures de dépollution aux sources probables des odeurs

mesurées en 1986 et 1987. On envisage de procéder de la même façon pour les autres sources. La question des odeurs fera d'ailleurs l'objet d'un nouvel arrêté d'intervention qui est en préparation.

KENORA

On a mesuré à l'une des quatre stations d'échantillonnage aux environs de l'usine de pâte au bisulfite quelques cas où l'objectif relatif aux retombées de poussières était dépassé. Selon l'arrêté d'intervention en vigueur, les rejets de particules de l'usine doivent être conformes aux règlements du Ministère d'ici la mi-1988.

MARATHON

Les odeurs mesurées près de l'usine de papier kraft se sont légèrement améliorées depuis 1986. Toutefois, les concentrations de soufre total réduit ont dépassé la ligne directrice à 93 reprises.

Il semblerait que les retombées de poussières de bois près de l'aire de stockage des copeaux de l'usine n'aient pas constitué un problème majeur en 1987. En général, les concentrations de poussières étaient conformes aux lignes directrices.

En 1989, l'usine effectuera un inventaire de ses sources d'émissions. Toutes les sources qui ne respectent pas les critères provinciaux feront l'objet d'un nouvel arrêté d'intervention.

RED ROCK

À quelques reprises en 1987, les émissions produites par les chaudières de l'usine locale de papier kraft dépassaient la ligne directrice du Ministère relativement aux poussières. En vertu d'un nouvel arrêté d'intervention qui sera délivré en 1989, l'usine devra améliorer ses méthodes afin de réduire ses effluents.

La ligne directrice concernant le soufre total réduit a été dépassée chaque fois que l'usine fermait son four à chaux. On s'attend que les travaux entrepris actuellement, conformément à l'arrêté d'intervention, permettent d'enrayer les émissions d'ici la fin de 1988.

TERRACE BAY

La qualité de l'air à Terrace Bay a diminué en 1987. En effet, on a mesuré 121 cas où la ligne directrice relative au soufre total réduit n'a pas été respectée, par rapport à 72 en 1986. Cela est dû, en grande partie, aux problèmes de fonctionnement du four à chaux appartenant à l'usine de papier kraft, située tout près. En vertu de l'arrêté d'intervention en vigueur, l'usine devra se conformer aux limites provinciales dès la mi-1989.

THUNDER BAY

Les retombées de poussières mesurées en 1987 à Thunder Bay étaient conformes aux limites du Ministère à neuf des dix stations d'échantillonnage. À un endroit, en effet, les retombées étaient légèrement supérieures à l'objectif provincial à cause des émissions de particules produites par l'usine locale de papier.

Par ailleurs, tous les échantillons de matières en suspension respectaient l'objectif annuel provincial. L'indice de souillure était également à un niveua acceptable pendant toute l'année.

Les concentrations de monoxyde de carbone, de dioxyde d'azote, d'ozone et d'anhydride sulfureux ont toujours été conformes aux critères provinciaux en 1987. On a relevé, à quelques reprises en juin, des concentrations élevées de soufre total réduit causées par des irrégularités de fonctionnement à l'usine de papier kraft.

INTRODUCTION

1.0 PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts an air quality assessment program throughout the province. This program records outdoor concentrations of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys document compliance with air quality objectives, and determine long-term air quality trends. The monitoring program identifies pollution sources and assesses the results of pollution control measures.

In northwestern Ontario, air quality surveys first began in 1963 to measure airborne dust in the City of Thunder Bay. By 1987, the Ministry's monitoring network had expanded to 10 communities, with more than 100 monitoring devices. Ten different pollutants can be measured, plus meteorological parameters. Ontario Hydro also has air quality networks in Thunder Bay and Atikokan.

Data from air quality and meteorological instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mining, pulp and paper). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and in parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout and is developing possible answers to this problem. The Ministry's Northwestern Region participates in this program through precipitation sampling surveys at 11 sites and through research on the aquatic, terrestrial, and biogeochemical effects of acid rain. The findings of these studies are reported elsewhere.

A major new development in the air quality program in northwestern Ontario is the installation of a telemetry system to greatly increase the speed with which data are received. This system was installed in late 1986. It permits the Ministry to obtain immediate readings from any continuous monitor in the region. An Air Quality Index (AQI) will be published four times daily for Thunder Bay, beginning in early June, 1988. The AQI will be based on readings for six pollutants: carbon monoxide, ozone, nitrogen dioxide, particulate matter (soiling index), sulphur dioxide, and total reduced sulphur. As resources permit, the publication of an AQI may be extended to other communities in the region.

2.0 POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario are considered. Hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

2.1 Particulate Matter

There are many man-made and natural sources of airborne particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may be harmful to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), and soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed.[1] The monthly air

quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days). The annual objective is 4.6 $g/m^2/30$ d. Dustfall estimates the fallout of particulate matter from local sources, including dust from construction or from vehicles. It is rarely considered to be a health-related pollutant, but may cause a significant nuisance because of soiling effects.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day.[2] The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air sampled) averaged over 24 hours, and 60 $\mu g/m^3$, annual geometric mean.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

2.2 Gaseous Pollutants

2.2.1 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. Its primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion. As the number of vehicles in northwestern Ontario is small relative to other parts of the province, carbon monoxide is not a problem pollutant in this region. Elevated concentrations of

carbon monoxide cause well-known health effects. The maximum acceptable level in Ontario is 30 ppm (parts of carbon monoxide per million parts of air), 1-hour average, and 13 ppm, 8-hour average. This pollutant is measured with a continuous analyzer[3] at one location in Thunder Bay.

2.2.2 Nitrogen Oxides (NO_x)

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both NO and NO_2 may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may adversely affect health and visibility. NO_2 also reacts with hydrocarbons in sunlight to form ozone. It may also combine with water to form nitric acid, a component of acid rain. Nitrogen oxides are monitored with continuous analyzers.[4] The air quality objectives for NO_2 are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

2.2.3 Ozone (O_3)

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a product of reactions between nitrogen oxides and hydrocarbons. If present at high concentrations, it may adversely affect health and damage vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. Ozone is measured with continuous analysers,[5] and the current air quality objective is 0.08 ppm, averaged over one hour.

2.2.4 Sulphur Dioxide (SO_2)

Sulphur dioxide is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health,

vegetation and property. It is also one of the main contributors to acid rain. In northwestern Ontario, the principal SO_2 sources are small compared to those in some other parts of the province. The main regional emitters of SO_2 are, in approximate descending order of importance, Ontario Hydro generating stations (Thunder Bay and Atikokan), sulphite pulp mills, gold ore roasting, and industrial boilers. SO_2 may be measured with passive samplers (sulphation plates) to provide a semi-quantitative estimate of the presence of sulphur-containing gases. Results are expressed as monthly sulphation rates, in mg SO_3/100 cm^2/d (milligrams of sulphur trioxide per 100 square centimetres of treated filter paper per day). Sulphur dioxide is also monitored with continuous analyzers.[6] There are three air quality objectives for this pollutant: 0.25 ppm, hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

2.2.5 Total Reduced Sulphur (TRS)

Total reduced sulphur comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS sources in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary discomfort to sensitive individuals. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS may be measured with sulphation plates, for semi-quantitative results, or with continuous analysers.[7]

2.3 Miscellaneous

The occurrence and effects of some of the foregoing pollutants, plus others, may be assessed by vegetation injury and by determining contaminant levels in vegetation, soil and snow. Standard Ministry procedures,[8,9,10] are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride,[11] sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background values at sites

unaffected by pollution. Contaminant guidelines developed by the Ministry for vegetation, soil and snow are used in this report. The guidelines are based on "normal" elemental concentration across the province. Exceedence of the guidelines would suggest that contamination may be present, but would not necessarily imply adverse effects.

Dustfall, sulphation, and suspended particulate matter determinations, as well as most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. The Ministry's Toronto laboratory analyses metals, nitrate, and sulphate in suspended particulate matter, and sulphur and halides (chloride, fluoride) in vegetation and soil. The Toronto laboratory also analyses unusual contaminants (e.g.: organic compounds such as PCBs or pesticides).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality and meteorological data for the region. During 1988, routine reading of charts will be phased out and replaced with data from the new air quality telemetry system. This system will allow the Ministry's Thunder Bay and Kenora offices immediate access to all continuously monitored air quality data across northwestern Ontario.

RESULTS

3.0 ATIKOKAN

3.1 Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began an air quality assessment program around a lignite-fired generating station under construction near Atikokan. Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples at several sites (Figure 1).

By late 1985, when the 200-megawatt plant went into service, at least three years of background data had been collected. A summary report for the pre-operational terrestrial and atmospheric deposition studies was issued in 1986.[12]

The Ministry and Ontario Hydro continued their monitoring programs during 1986 and 1987, the first two operational years for the power plant. Ontario Hydro's environmental quality compliance reports show that no exceedences of Ontario's air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide were recorded in either year. A report (in preparation) on 1986 atmospheric deposition and terrestrial data revealed no significant changes from the pre-operational period. The present assessment program will continue at least to the end of 1988, then will be reviewed and amended as appropriate.

In 1987, at the Ministry's long-term monitoring site in the Town of Atikokan (station 62013, Figure 2), all but 2 of the 55 TSP samples met the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 26 $\mu g/m^3$ also complied with the limit of 60 $\mu g/m^3$, and was similar to values for preceding years.

3.2 Pluswood Manufacturing

A small 4-station network (Figure 2) was established in October, 1987, to monitor dustfall near Pluswood Manufacturing Limited. This company produces particleboard. For the 3 months of data for the year, dustfall levels at all four sites met the Ontario objective of 7.0 $g/m^2/30$ days.

4.0 BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson-Sullivan Joint Venture, Arthur W. White Mine (formerly Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore

roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson shut down its roaster.

4.1 Arsenic

In 1987, arsenic concentrations in leaves of trembling aspen trees at 17 sites near the mines (Figure 3) remained elevated on company property but were near normal levels in the townsite. The elevated arsenic on company property is ascribed to localized fugitive emissions from arsenic-containing wastes or from concentrates. Stack emissions may also contribute to arsenic fallout. Table 1 compares arsenic readings for the past 5 years at selected sites on and off company property. Table 2 presents data for the same period from planted roadside trees in the townsite. Both tables show that current arsenic levels in tree vegetation in the townsite are above normal background concentrations. Apart from site 2 on Campbell's property (Table 1), arsenic concentrations in 1986 and 1987 were similar. Vegetation at site 2 may have been influenced in 1987 by wind-blown wastes from the Campbell tailings area.

Arsenic in garden vegetables was below the former limit (approximately 10 μg/g, dry weight) specified by the Health Protection Branch, Canada Department of Health and Welfare (Table 3). Because arsenic in garden soil remains high, Balmertown residents are advised to thoroughly wash vegetables from their gardens.

4.2 Mercury

Because mercury has been used in ore processing at the mines, the Ministry regularly examines mercury levels in the local environment. Mercury slightly exceeded the Ministry's contaminant guideline in trembling aspen leaves at one site on company property near each of the two mines, but was normal in the townsite. All vegetable samples from residential gardens met the recommended international guideline for mercury (0.5 μg/g, dry weight).

Campbell Red Lake discontinued the use of mercury in late 1982, but it is still used at Dickenson.

4.3 Sulphur Dioxide

Sulphur dioxide sometimes exceeds desirable levels in Balmertown. In 1987, the Ministry's Balmertown monitor recorded 87 hourly SO_2 readings and seven, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.95 ppm, about four times the Ontario objective. The annual average (0.010 ppm) was satisfactory. In 1987, there was no visible sulphur dioxide injury to vegetation recorded either on or off company property.

During the growing season (May to September), SO_2 was above the acceptable hourly limit 23 times, compared with 28 occasions in 1986 and 61 times in 1985. Over the past 10 years, there has been no clear trend in the number of exceedences of the hourly limit. Table 4 summarizes the data for the past 5 years. To avoid significant vegetation damage, Campbell Red Lake Mines has an SO_2 abatement program, under which its ore roaster is shut down when the wind carries roaster-stack emissions over the townsite during the growing season.

5.0 DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and adjacent chlor-alkali plant in Dryden. Abatement action, process changes, and mill modernization have resolved most of the air quality concerns of the 1970's and early 1980's. Currently, the Ministry monitors odour levels in the town centre, and measures sulphation rates around the mill's secondary treatment system (lagoon). The mill owners, Great Lakes Forest Products Limited, began a one-year survey of suspended particulate matter in the town centre in July.

5.1 Lagoon

A secondary treatment system (lagoon) was constructed in late 1983 to process effluent from the Dryden mill. Initially, wind-blown foam and odours from the lagoon caused a nuisance to area residents. The foam problem has now been resolved. Special Ministry studies in 1985 found no evidence of potential health effects from airborne substances near the lagoon.[13] Measurements from eight sites (Figure 4) revealed very low sulphation rates throughout 1987. Nearly 93% of the values were below the detection limit. These results indicate that average monthly odour levels around the lagoon were low during the year.

5.2 Kraft Mill

5.2.1 Particulate Matter

With one exception, TSP concentrations recorded in the town centre complied with the provincial objective between mid-July (start of monitoring) and the end of the year. One elevated reading, the cause of which is unknown, was obtained in mid-October.

5.2.2 Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with a continuous TRS analyzer in central Dryden (station 61027, Figure 4). As Table 5 shows, air quality in 1987 continued the trend of improvement shown in recent years. The provincial guideline for TRS was not exceeded at any time during the year. This excellent achievement in pollution control is displayed graphically in Figure 5. This chart shows guideline exceedences dropping from several hundred a year in the late 1970's to no exceedences in 1987.

6.0 FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in particulate fallout and odour problems in a nearby residential area. In the late 1970's, some emission reductions were achieved. In 1980, a Control Order was issued for further pollution controls. The mill also created a "buffer zone" through purchase of adjacent residential land.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and periodically since 1974 around a similar plant owned by the parent corporation on the U.S. side of the border nearby (Figure 6).

6.1 Vegetation Effects

In 1987, there was trace to moderate air pollution injury on foliage of only two Manitoba maple trees in the buffer zone around the Fort Frances mill. There was no new vegetation injury outside this zone. Sodium in tree foliage was low in 1987 samples (Table 6), possibly because of wash-off caused by heavy rain a few days before the sampling date. For this reason, and because it applies only for the growing season, vegetation analysis is not as reliable as dustfall measurements for determining saltcake fallout. The decline in foliar chloride levels during the past few years (Table 6) suggests that emissions of chlorine and chlorine compounds from the mill may also have decreased.

There was no visible off-property damage to vegetation around the secondary effluent treatment system on Eighth Street (Figure 7).

6.2 Particulate Matter

Dustfall results for 1987 are summarized in Table 7. The annual air quality objective for dustfall was met at only the two most distant sites from the mill (stations 62032 and 62037).

On-property dustfall averaged more than twice the objective. Dustfall just outside mill property was about 60% above the objective. Wood fibres accounted for about 25 to 75% of total dustfall when high dustfall readings occurred at sites around the mill off company property (stations 62034, 62035, 62036 and 62050). Saltcake comprised about 20% of total dustfall at these locations. Road dust, fly ash, and insect parts were also sometimes present in significant amounts in dustfall, mainly during the summer. A comparison of average dustfall during recent years (Table 8) shows no significant trend, although the decline from 1986 to 1987 is encouraging. The enlargement and rebuilding of the recovery boiler precipitator at the Fort Frances kraft mill, to be completed in early 1989, should significantly reduce fallout of saltcake.

In common with dustfall, total suspended particulate matter (TSP) showed no significant change in 1987 from earlier years. The annual average TSP at the monitoring site near the mill (station 62035) was 62 $\mu g/m^3$, slightly above the provincial objective. Twelve of the 51 daily readings at this site exceeded the 24-hour objective. Highest levels occurred with south to southwest wind, when the monitor was downwind of the mill. The annual average TSP at the Fort Frances cemetery (station 62032) was 29 $\mu g/m^3$, which is normal for this location and well within the Ontario objective. There were no exceedences of the daily objective at this site.

6.3 Odour Levels

Sulphation rate averages in Fort Frances have shown little change during the past few years (Table 9). The number of exceedences of the TRS guideline in 1987 (Table 10) increased from the levels in 1985 and 1986 at both Ministry monitoring sites. While air quality declined in 1987, it was still much better than it was 8 to 10 years ago. Figure 8 displays the daily variation in TRS concentrations at station 62030. The trend of higher readings at night and lower levels at mid-day is due to normal atmospheric conditions and not due to daily variation in TRS emissions. A similar pattern has been found near some other pulp mills in the region.

Unexpected emissions from one source at the Fort Frances mill probably contributed to higher TRS levels in 1987. Emissions from this source will be significantly curtailed in 1988. Other odour control action at the mill is being considered. Process improvements at the secondary treatment lagoon should also reduce odour emissions from this source by early 1989. Odour abatement will be addressed in a new Control Order now being negotiated with mill management.

The Ministry also plans to install two more TRS monitors in Fort Frances. These monitors will provide better coverage of the town and will help identify more accurately the sources contributing most to the odour problem.

7.0 KENORA

For many years, the Ministry has monitored air quality near a sulphite pulp mill in Kenora. The current monitoring program includes dustfall and sulphation measurements at four locations (Figure 9).

7.1 Particulate Matter

As Table 11 shows, average dustfall in Kenora in 1987 was somewhat lower than the average for the preceding 4 years. Dustfall frequently exceeded the monthly objective at station 61007. Levels at the other three sites were usually acceptable. Wood or bark char and woodfines were major components of dustfall when elevated readings occurred. A Control Order requires the mill to comply with Ministry regulations for particulate matter by June 30, 1988.

7.2 Sulphation Rates

Average sulphation rates in 1987 were marginally higher than those in 1986 (Table 12), but this difference is not significant. As a result of a successful abatement program, there has been no evidence of a sulphur dioxide problem near the mill for several years.

8.0 MARATHON

The Ministry currently maintains five air quality monitoring stations in Marathon (Figure 10) and one in Heron Bay. The purpose of the Ministry's assessment program is to monitor odour levels near the kraft pulp mill operated by James River-Marathon Limited. The company also has dustfall jars at five sites near its wood chip piles to measure fallout of particulate matter.

8.1 Particulate Matter

The fallout of wood fines from wood-chip piles near the pulp mill ("wood storage area", Figure 10) has been studied by the company and by the Ministry.[14] Dustfall measurements for 1987 by the company and the Ministry indicate general compliance with dustfall objectives at sites off company property. Steps have been taken to reduce dust emissions from the chip piles. Monitoring will continue.

8.2 Odour Levels

Table 13 shows that average sulphation levels in the townsite have declined slightly during the past 5 years. Average annual TRS also decreased marginally from 1986 to 1987, and the number of guideline exceedences dropped about 20% (Table 14). To alert the mill when community odour levels exceed the desirable limit, the company telemeters TRS readings directly from the Ministry's monitor to the mill. The mill will be carrying out another emission inventory in 1989. Any sources identified by the inventory as not in compliance with regulations will require further abatement action, and will be addressed in a new pollution Control Order.

9.0 RED ROCK

The Ministry operates a small air quality monitoring network in the Town of Red Rock to measure dustfall and odour levels near a

kraft pulp mill. The network comprises four dustfall jars at stations 63080 to 63083, and a continuous TRS analyser at station 63084 (Figure 11).

9.1 Particulate Matter

Table 15 summarizes dustfall in Red Rock for the past 5 years. During this time, average dustfall in the townsite has varied but there has been no clear trend. In 1987, one of the three monitoring sites off mill property met the annual air quality objective; dustfall at the other two sites was slightly above the desirable limit. Most of the infrequent exceedences of the monthly objective were caused by wood or bark char, or by wood fines. Ministry staff observed char particles on streets, in dustfall jars, and on snow from time to time during the year. This fallout was caused by emissions from wood waste-fueled power boilers at the pulp mill. Controls on these discharges will be required in the next Control Order.

9.2 Odour Levels

There were 203 exceedences of the TRS guideline in 1987 (Table 16). Since 1982, when a new recovery furnace was installed at the pulp mill, community odour levels have fluctuated widely. In 1987, nearly half the exceedences of the TRS guideline occurred during scheduled or unscheduled shutdowns of the lime kiln, where odourous non-condensable gases (NCG) are burned. Under the present Control Order, the TRS guideline must be consistently met by the end of 1988. To achieve compliance, the company will be improving its steam stripping and NCG system. Emission monitoring for TRS or equivalent will also be carried out.

10.0 TERRACE BAY

The Ministry's monitoring program in Terrace Bay is directed toward measurement of odour levels in the townsite and at three points where an effluent ditch from the local kraft pulp mill crosses the TransCanada Highway (Figure 12).

10.1 Odour Levels

Average sulphation rates in 1987 were slightly lower than those preceding years (Table 17), but this difference was not significant. TRS data (Table 18) showed that during the year there were 121 hourly readings above the provincial guideline of 27 ppb at the Ministry's monitoring site (station 63090, Figure 12). The maximum hourly average was 159 ppb. The 1987 results shows that air quality declined, compared to the preceding 4 years. During 1987, the mill had problems with lime kiln operations. As a result, odourous non-condensable gases were vented to atmosphere instead of being incinerated in the kiln.

TRS data from the Ministry's monitor are continuously telemetered to the mill. Under the 1987 Control Order, Kimberly-Clark will be putting process improvements in place to reduce odour emissions. The Control Order calls for compliance with the TRS guideline by June, 1989. To record odours on Highway 17, the Ministry plans to install a continuous TRS monitor near the point where the mill's effluent canal first crosses the highway.

11.0 THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 13. Thunder Bay's first "full" air monitoring station (63200) was placed in service on South James Street in late 1986. At this station, sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, particulate matter (soiling index) and total reduced sulphur are continuously recorded. Three of the Ministry's Thunder Bay monitoring stations (63005, 63022 and 63200) are part of Environment Canada's NAPS (National Air Pollution Surveillance) network. Ontario Hydro operates five sulphur dioxide monitors in Thunder Bay. It also has dustfall jars on and near its Mission Island property to measure dust from flyash disposal and coal storage areas around its power plant. The following discussion reviews air quality data from the Thunder Bay area, and includes brief summaries of some special studies carried out during the year.

11.1 Particulate Matter

11.1.1 Dustfall

Dust emitted from grain elevators was formerly a nuisance to Thunder Bay residents. Dustfall measurements near the elevators began in 1970, and the monitoring network has been revised periodically since then. The 1987 data for the 10 sites now in service are summarized in Table 19. During the year, average dustfall was below the maximum acceptable limit at 9 of 10 sites.

At Totem Trailer Court (site 63047), near Great Lakes Forest Products, dustfall slightly exceeded the maximum desirable level. Flyash was the main contributor to two elevated monthly readings at this location. Insect debris caused one monthly exceedence at the Main Street site (63019). All other monthly values in the network met the provincial objective. Figure 14 shows a satisfactory downward trend for dustfall in Thunder Bay over the past 15 years.

11.1.2 Suspended Particulate Matter and Soiling Index

Total suspended particulate matter was generally very satisfactory throughout Thunder Bay in 1986 (Table 20). About 98 percent of the total samples of all six monitoring sites were below the 24-hour maximum acceptable limit of 120 $\mu g/m^3$. All but one of the seven exceedences of this limit occurred at station 63046 (Montreal Street). The high readings at this site were caused mainly by nearby construction work during spring months. The annual objective was met at all locations. As the trend graph for 15 years shows (Figure 15), this objective has been achieved for many years.

Filters from the two city-centre stations (stations 63005 and 63022) had acceptable concentrations of heavy metals, including lead. Reflecting the reduced use of lead in gasoline, airborne lead levels in Thunder Bay have declined over the past 15 years (Figure 16). Levels of sulphate and nitrate, which are influenced by long-range transport, varied considerably in 1987.

At station 63200, soiling index met the daily and annual air quality objectives.

11.2 Gaseous Pollutants

11.2.1 Carbon Monoxide, Nitrogen Dioxide and Ozone

Throughout the year, carbon monoxide was well below the maximum acceptable limit for 1-hour and 8-hour averages at station 63200. Nitrogen dioxide met the hourly and 24-hour objectives. Ozone did not exceed the provincial 1-hour objective of 0.08 ppm. Ozone, a long-range transport pollutant, is not currently considered a problem in northwestern Ontario.

11.2.2 Sulphur Dioxide

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt lignite-fired generating station and four pulp and paper mills. Collectively, these sources are relatively small; total SO_2 emissions in Thunder Bay are less than 100 metric tons per day. The network of seven SO_2 monitors (five belonging to Ontario Hydro and two owned by the Ministry) showed full compliance for all SO_2 air quality objectives in 1987 (Table 22).

11.2.3 Total Reduced Sulphur

At the Ministry's Montreal Street monitoring site (station 63046), the TRS guideline (27 ppb) was exceeded for 12 hours in 1987 (Table 23). These exceedences, which all occurred during the last half of June, were caused by temporary operating irregularities at the Great Lakes Forest Products Limited kraft pulp mill. These conditions are not expected to recurr.

11.3 Special Studies

11.3.1 Albright and Wilson Americas

A vegetation assessment survey was carried out near Albright

and Wilson Americas, which manufactures sodium chlorate for the pulp and paper industry. The plant was found to be a minor source of airborne chloride and sodium, and a very small source of chromium.[15] There was no evidence that these emissions were causing an environmental problem; no abatement action was recommended.

11.3.2 Thunder Bay Terminals Limited

A report on 1987 air quality monitoring near Thunder Bay Terminals Limited[16] showed that this facility continued to operate satisfactorily. Western coal and potash are the main products handled. There has been no increase in dust levels at off-property monitoring sites since shipments began in 1978.

ACKNOWLEDGEMENT

The assistance of staff of the Atmospheric Environment Service, Atikokan Weather Station, for operating a high volume sampler is gratefully acknowledged.

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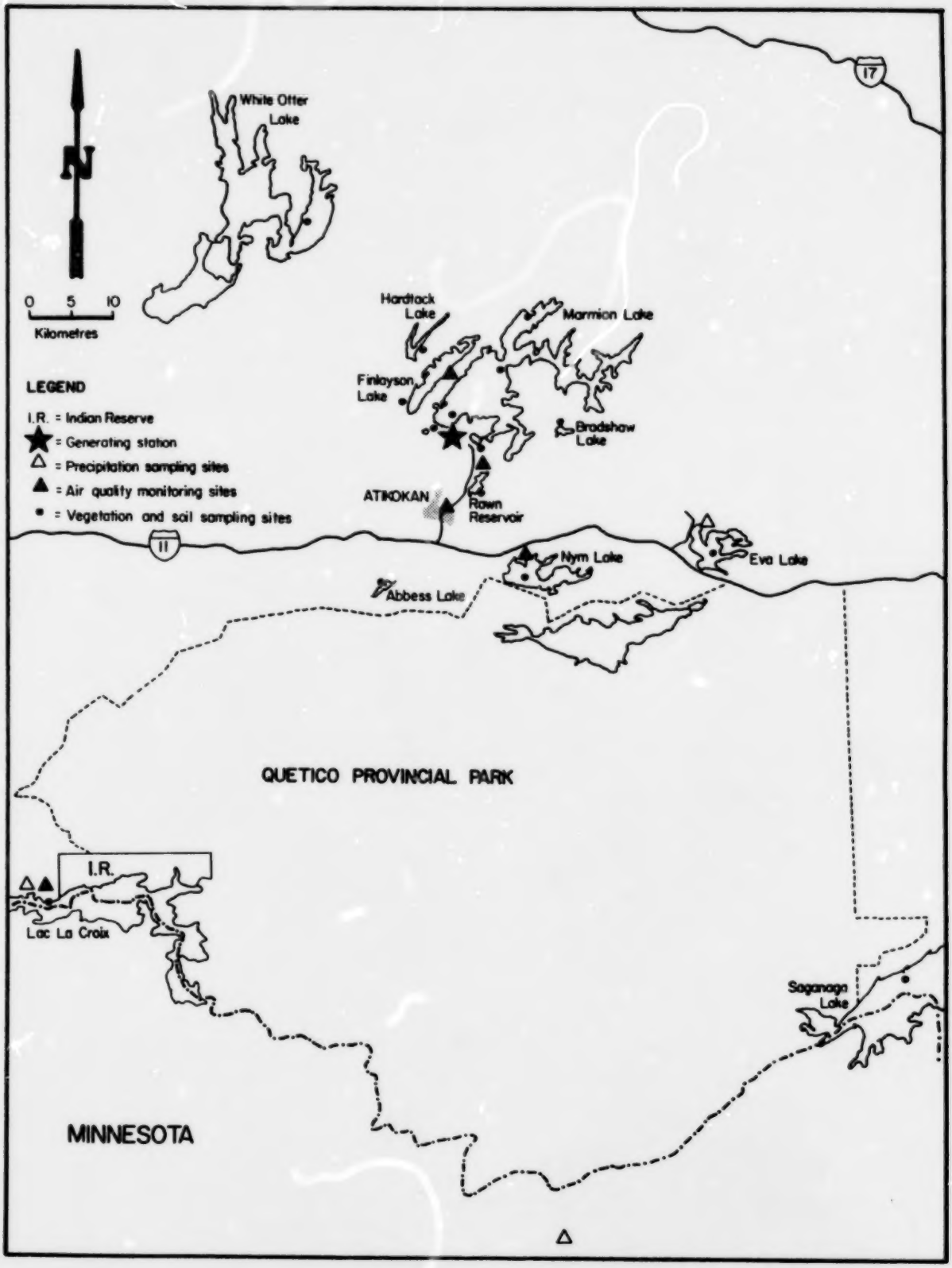

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

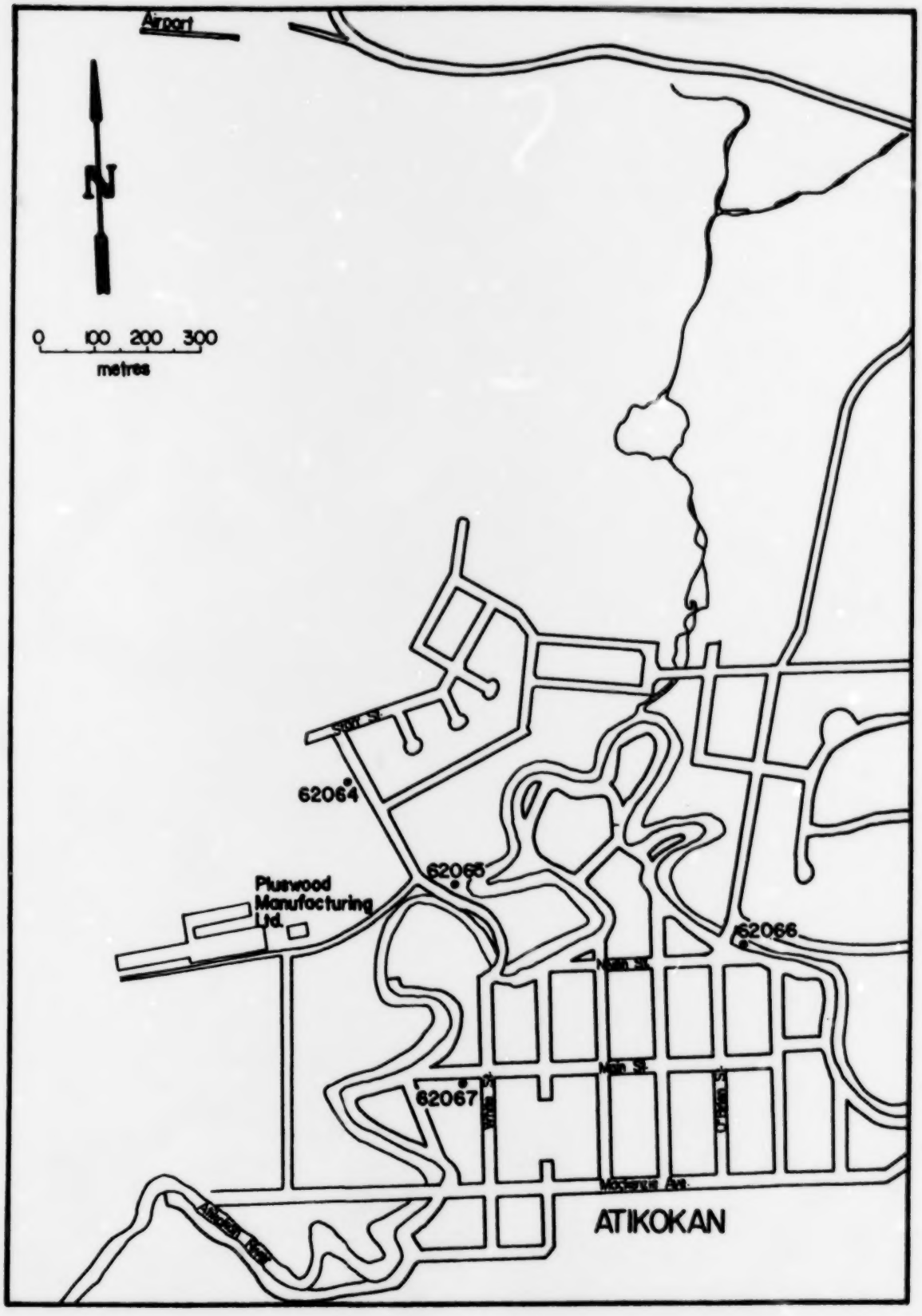

Figure 2. Air quality monitoring sites near Pluswood Manufacturing Ltd., Atikokan, 1987.

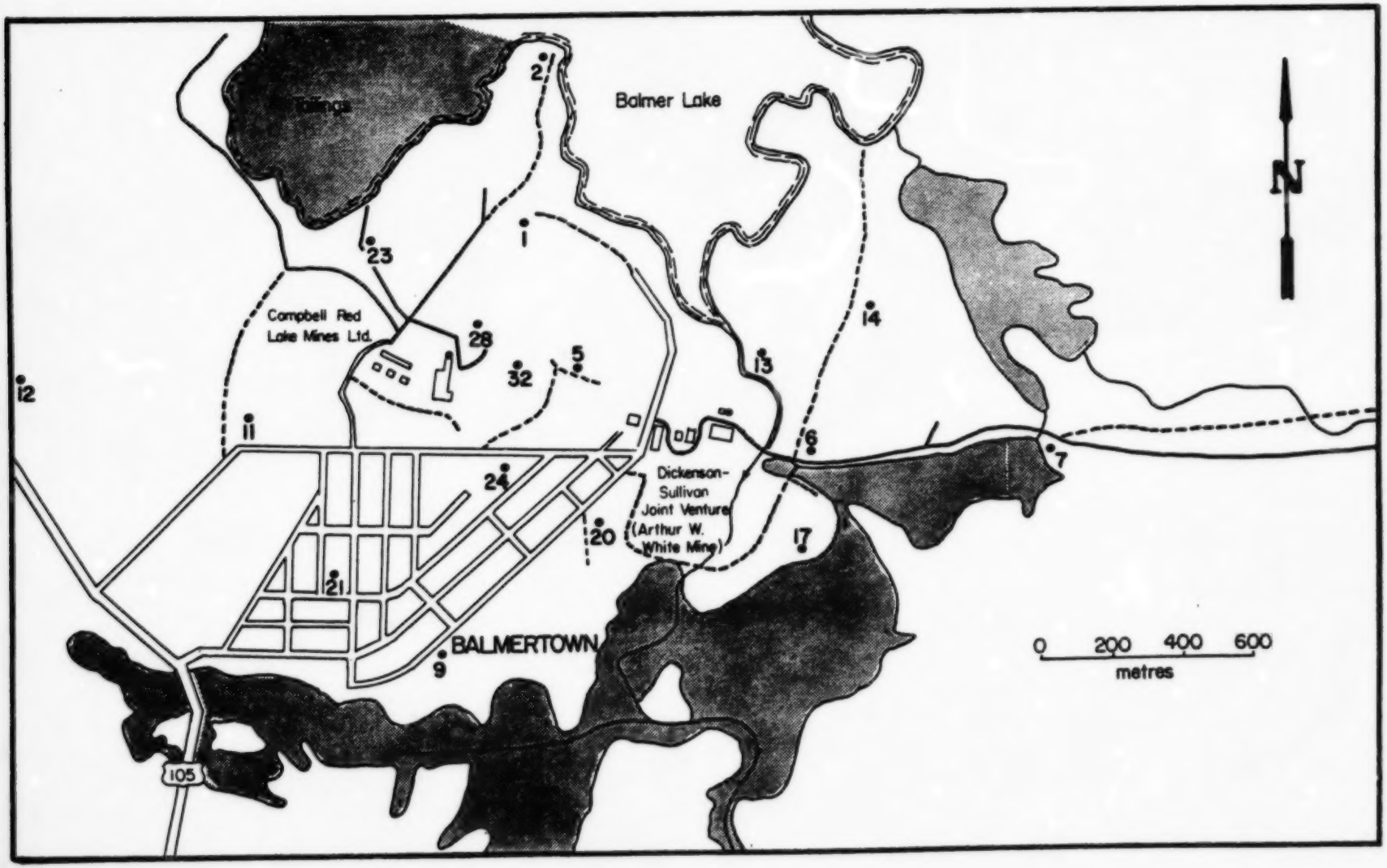

Figure 3. Trembling aspen sampling sites, Balmertown, 1987.

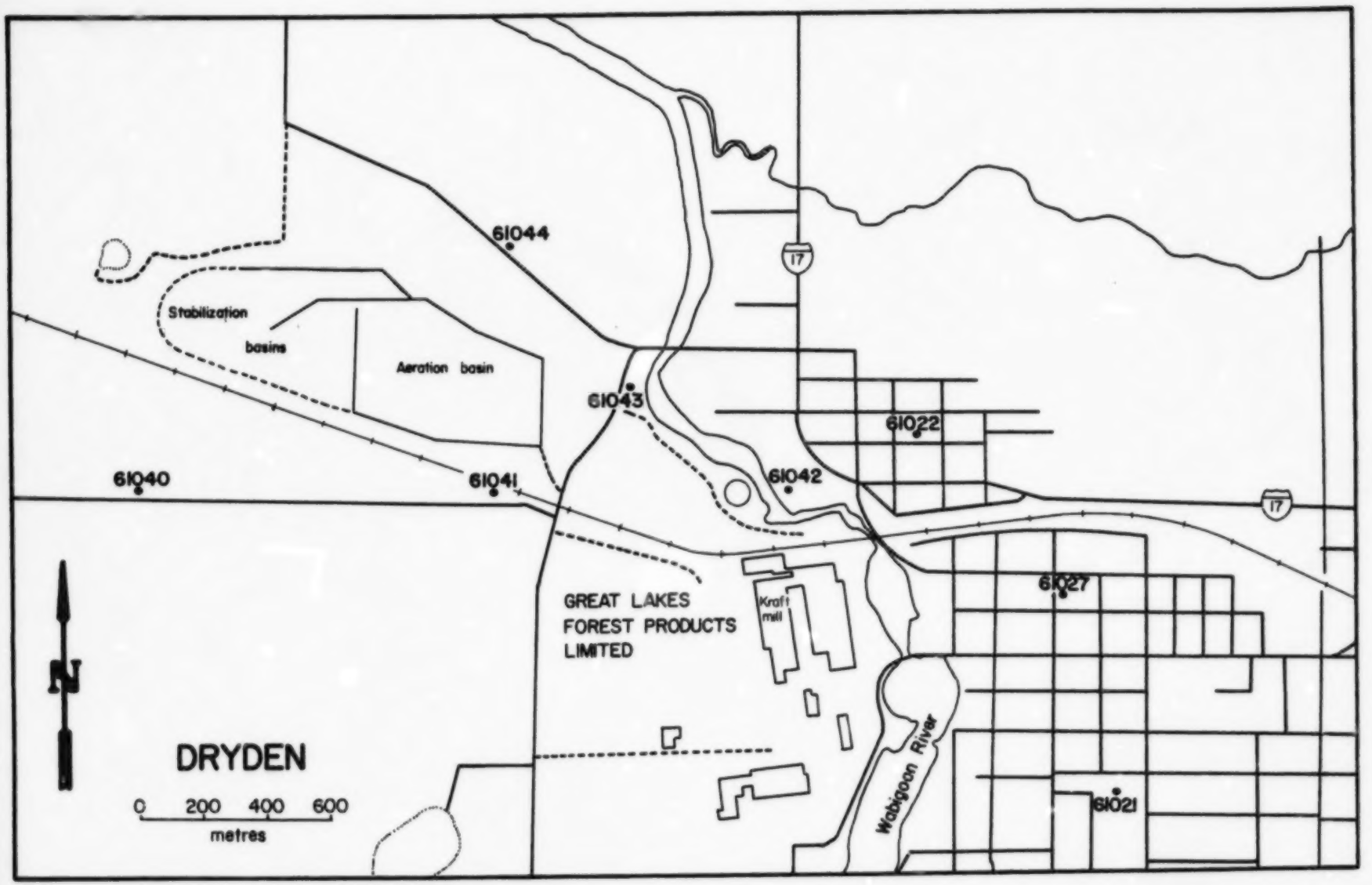

Figure 4. Air quality monitoring sites, Dryden, 1987 (Sulphation plates at all sites; continuous TRS monitor at 61027).

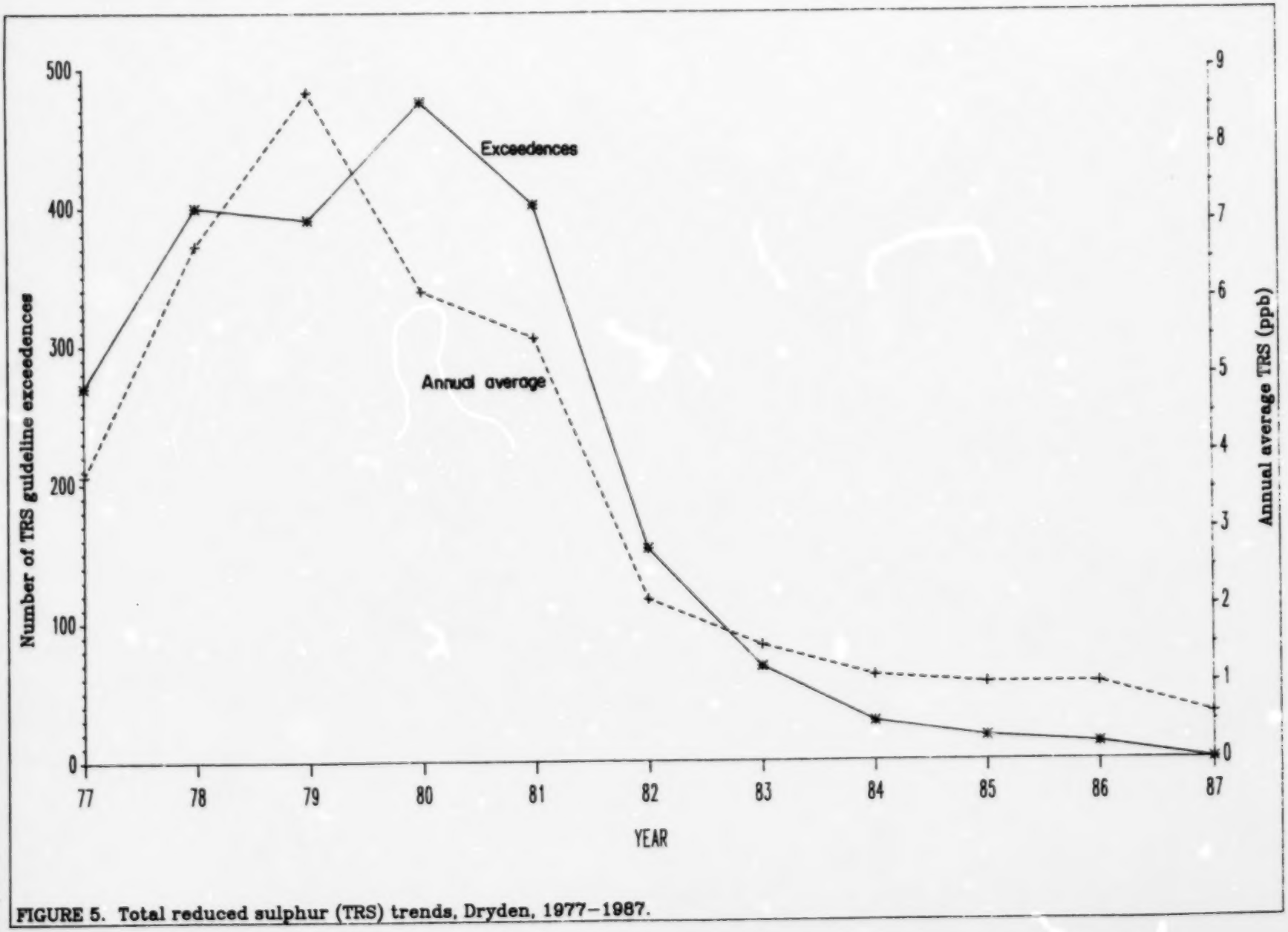

FIGURE 5. Total reduced sulphur (TRS) trends, Dryden, 1977–1987.

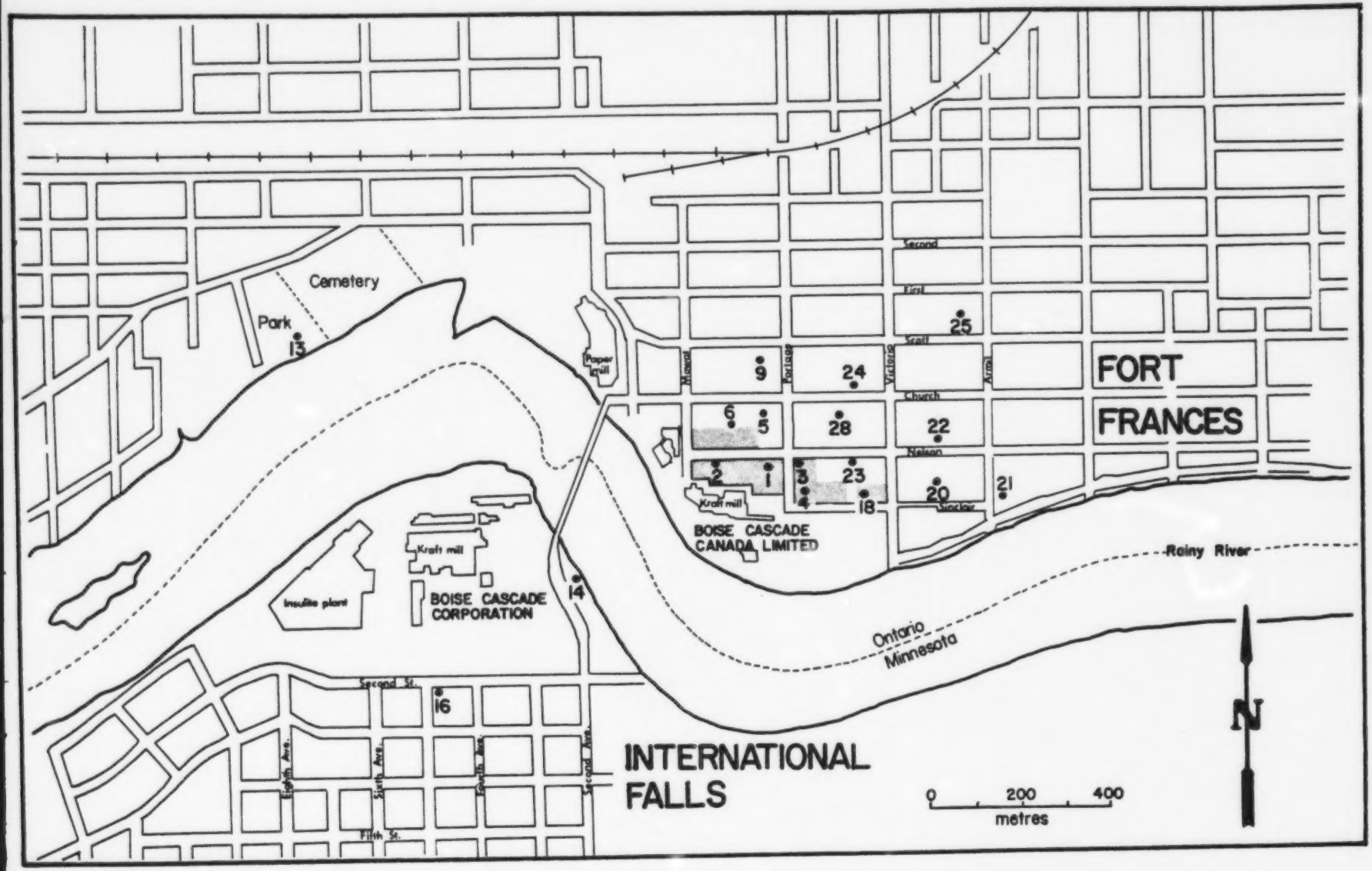

Figure 6 . Manitoba maple sampling sites, Fort Frances, August, 1987. Buffer zone

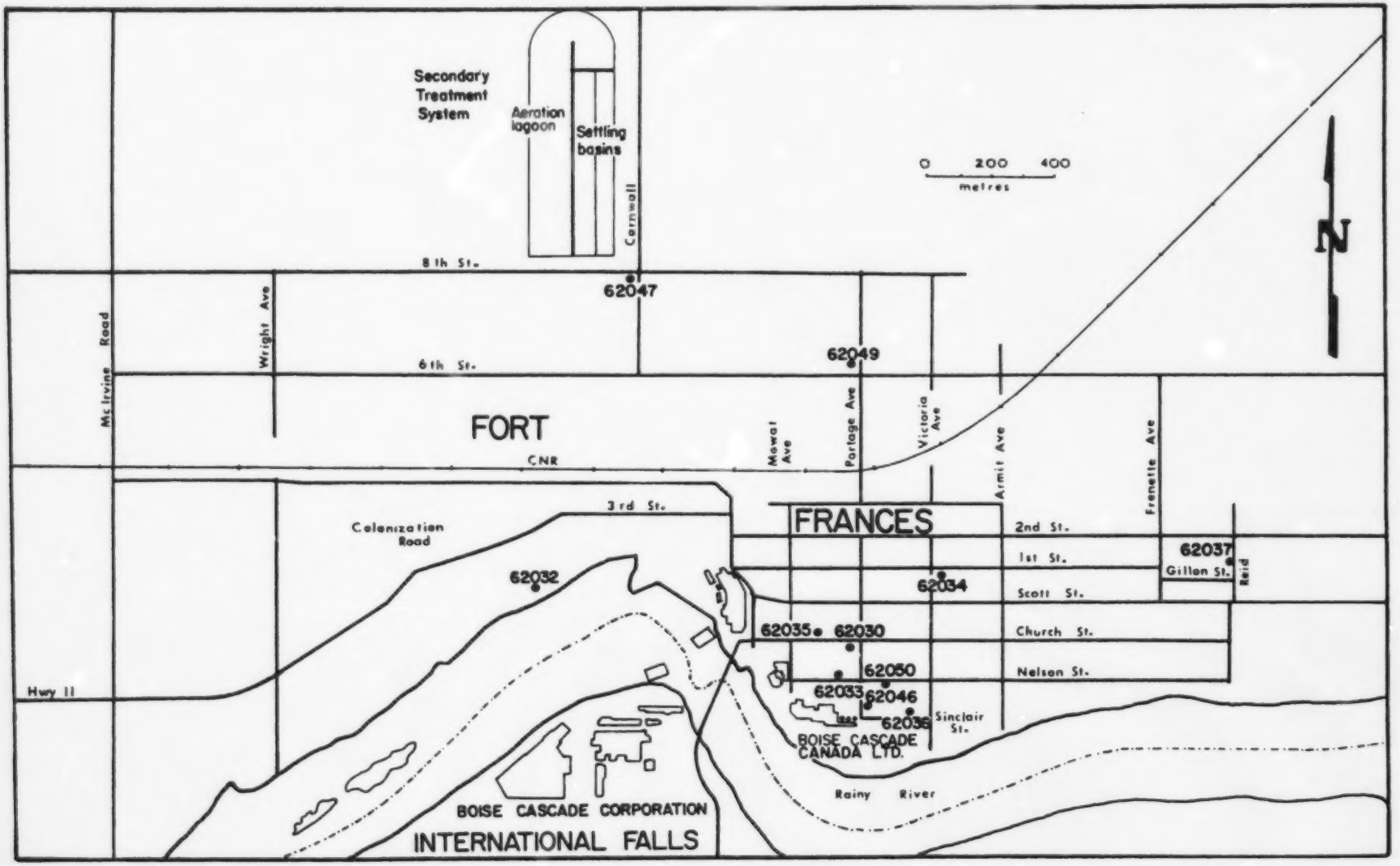

Figure 7. Air quality monitoring sites, Fort Frances, 1987.

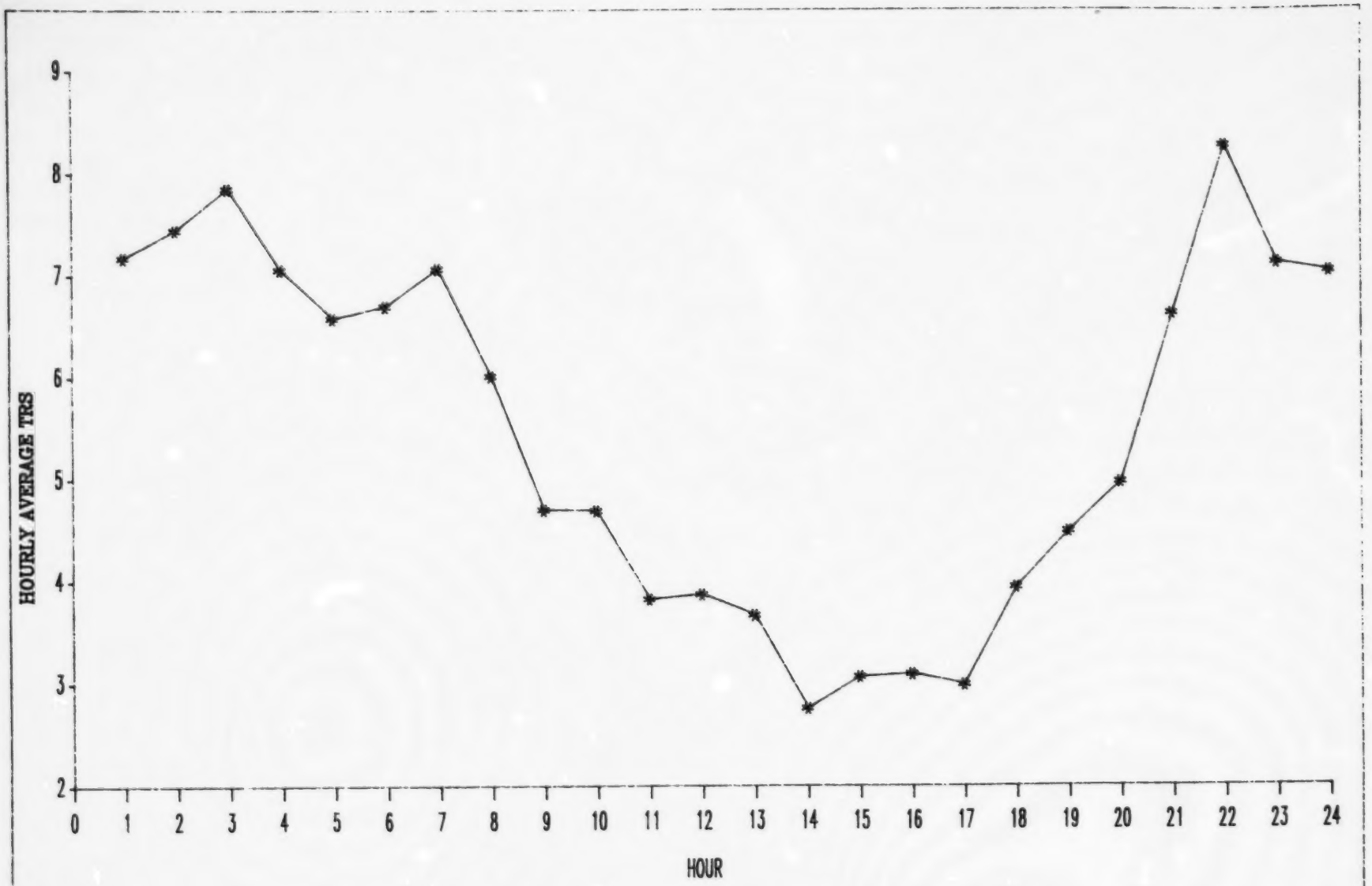

Figure 8. Daily average total reduced sulphur levels, (parts per billion) station 62030 , Fort Frances, 1987.

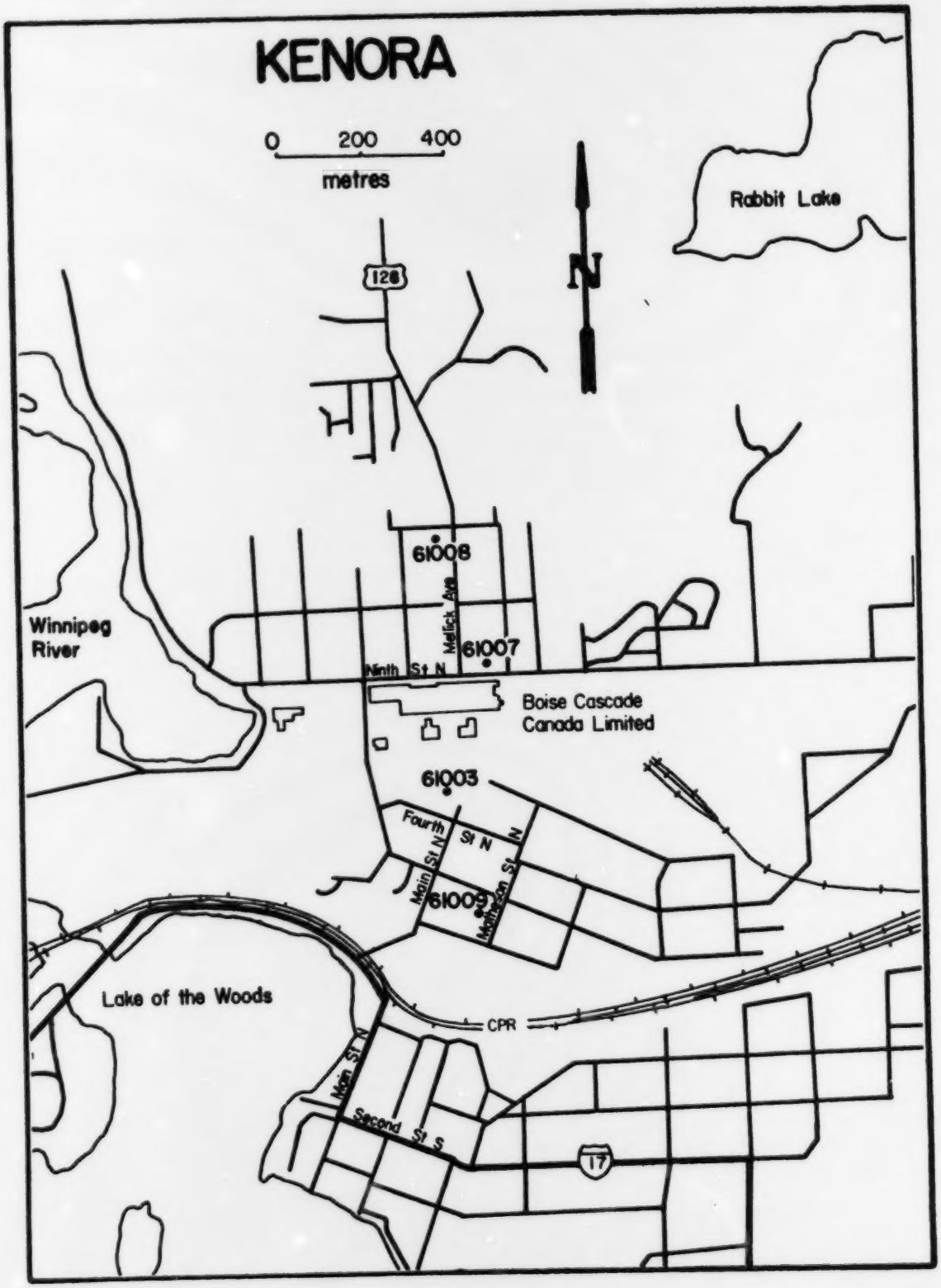

Figure 9. Air quality monitoring sites, Kenora, 1987.

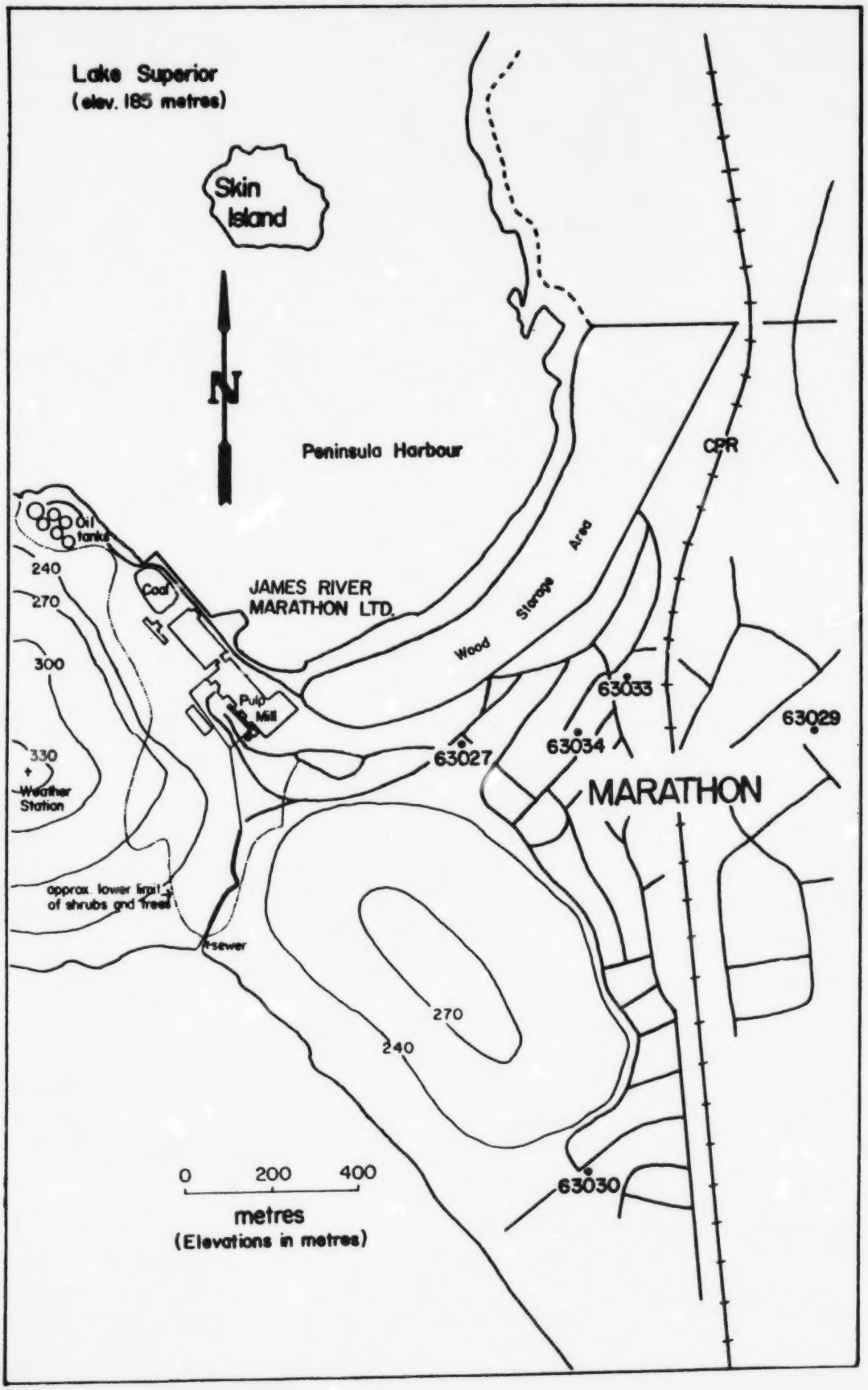

Figure 10. Air quality monitoring sites, Marathon, 1987 (except station 63032, Heron Bay).

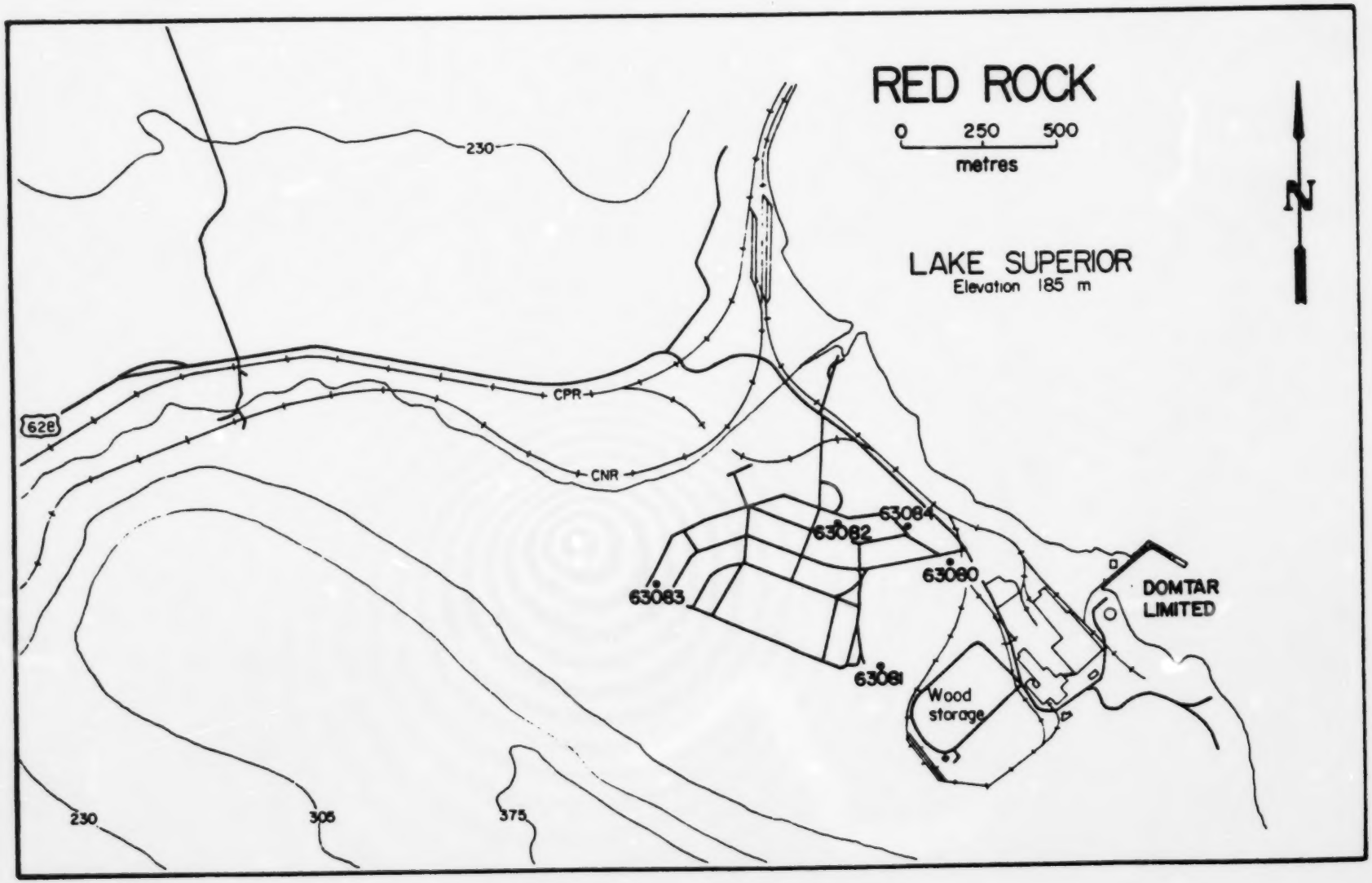

Figure II .Air quality monitoring sites, Red Rock, 1987 (TRS only at 63084).

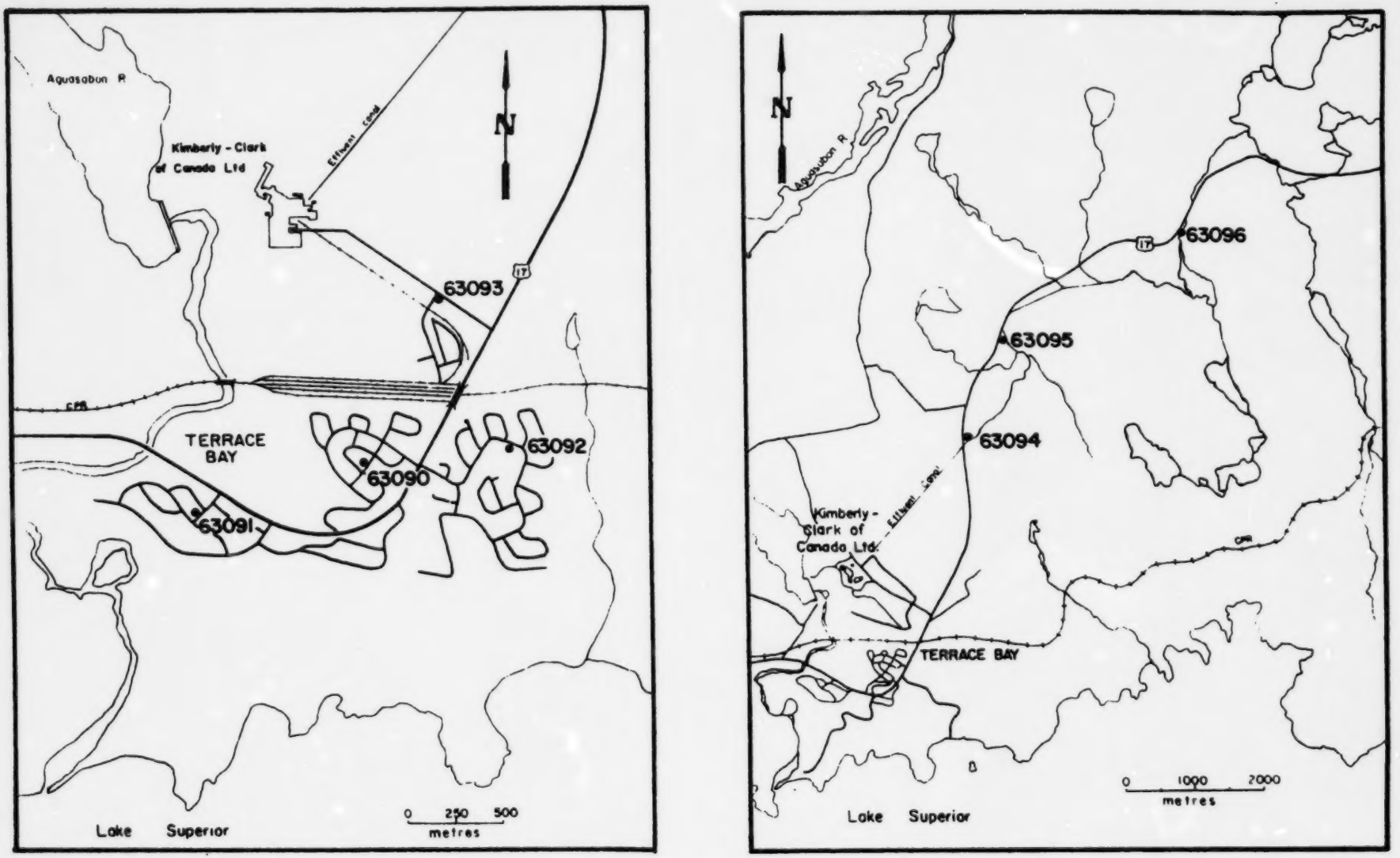

Figure 12. Air quality monitoring sites, Terrace Bay, 1987. (TRS at station 63090 only).

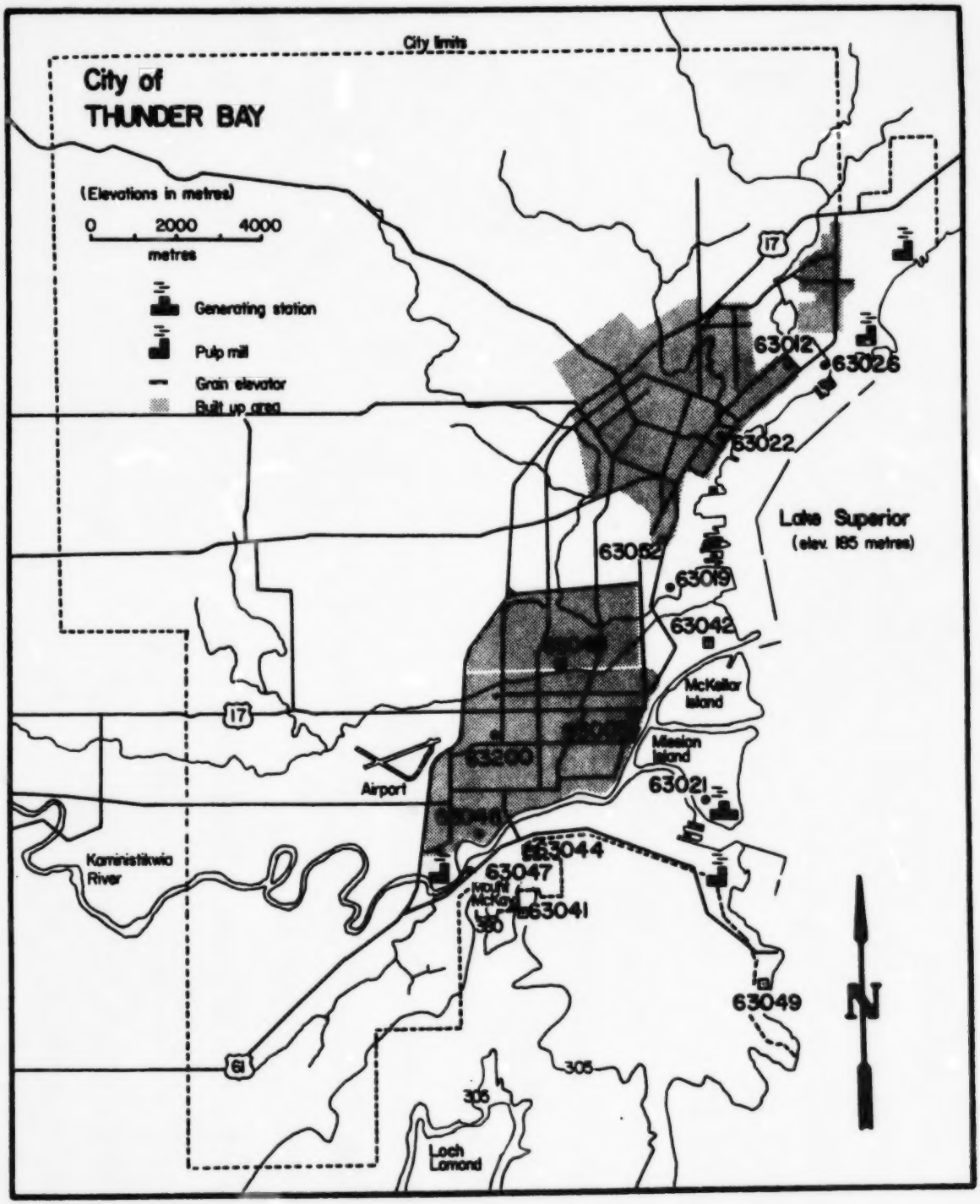

Figure 13. Air quality monitoring sites, Thunder Bay, 1987.

(⊡ Ontario Hydro sites)

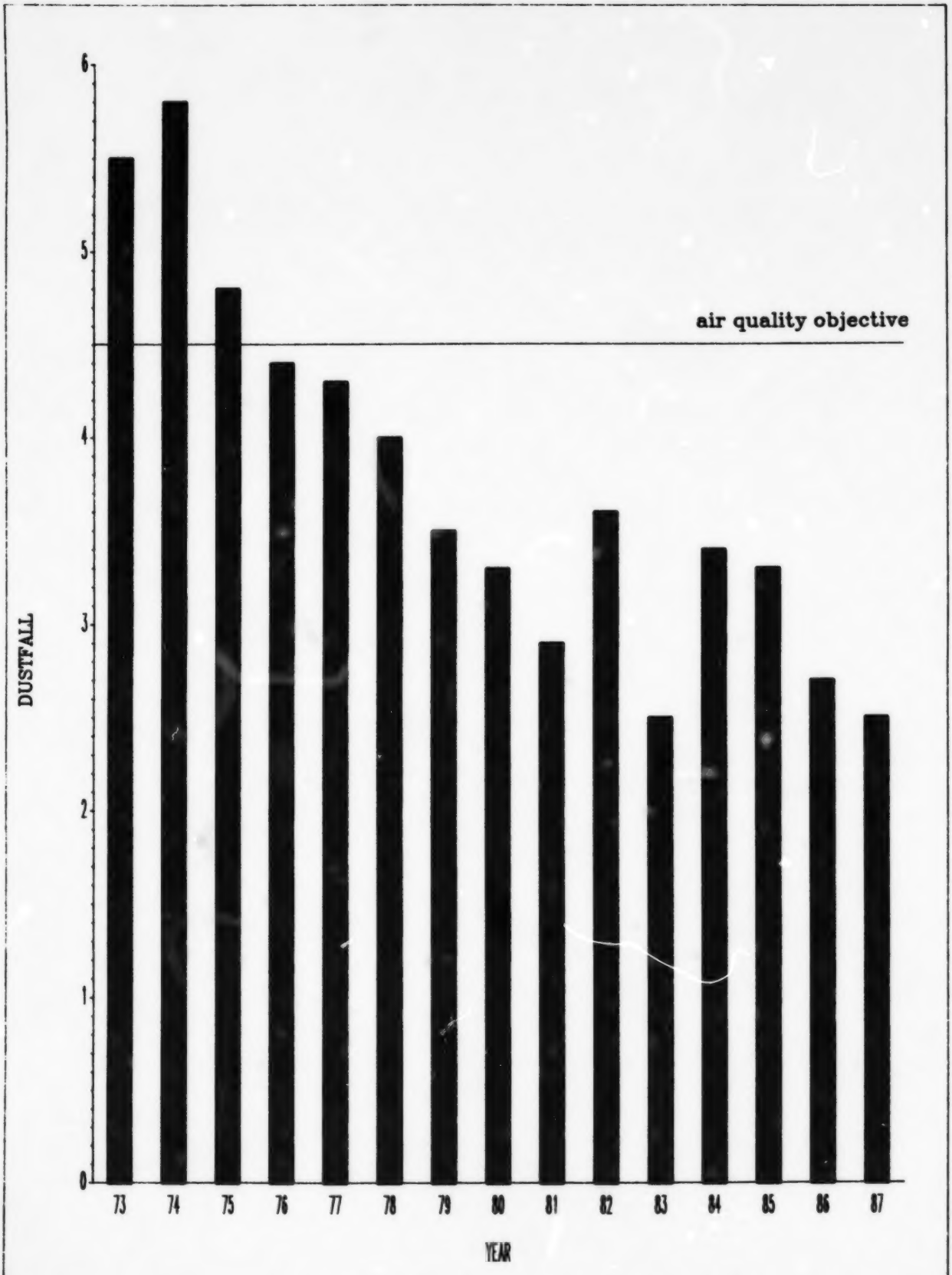

FIGURE 14. Average annual dustfall ($g/m^2/30$ d) at six sites, Thunder Bay, 1973–87.

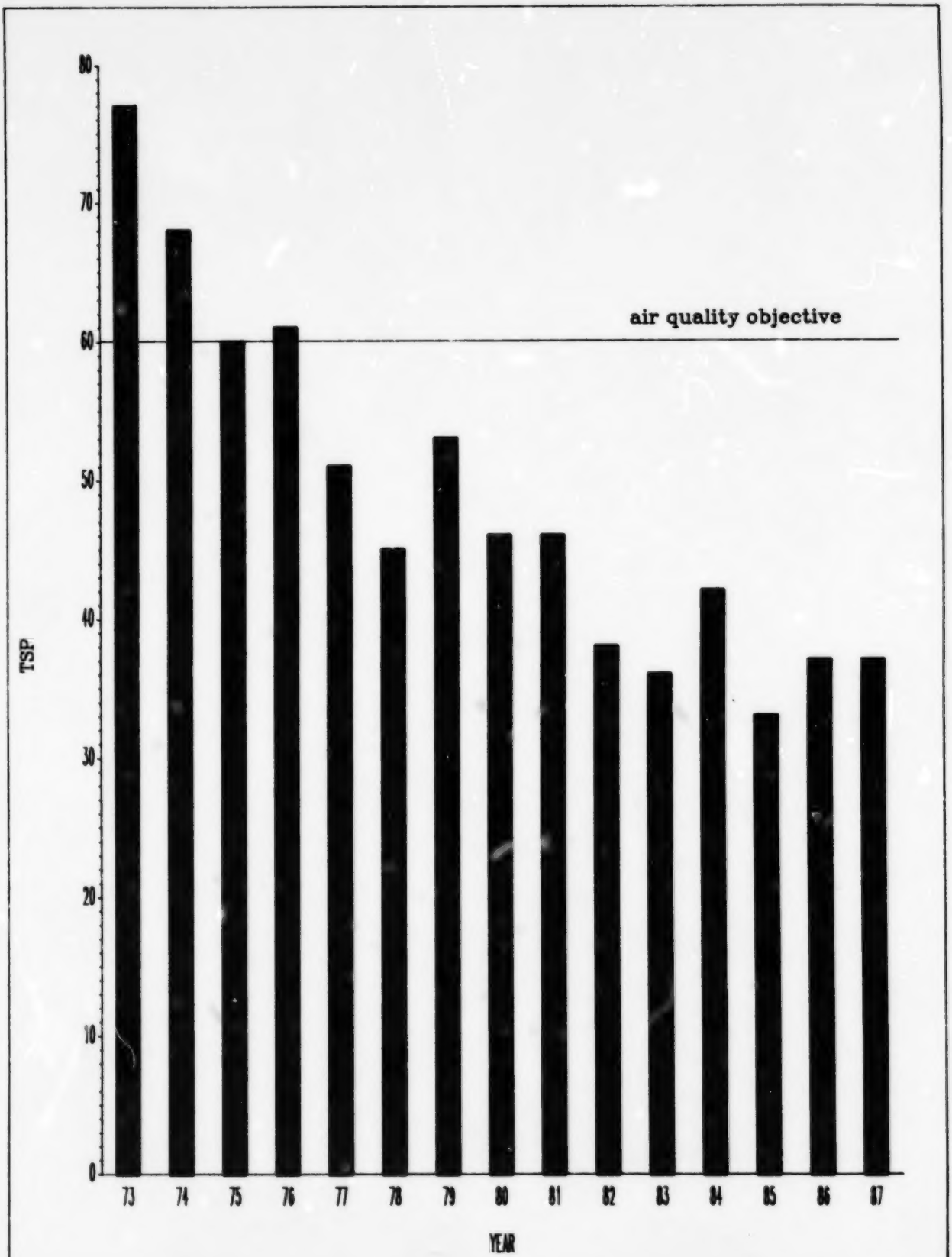

FIGURE 15. Average total suspended particulate (TSP) matter (ug/m^3) at four sites, Thunder Bay, 1973–87.

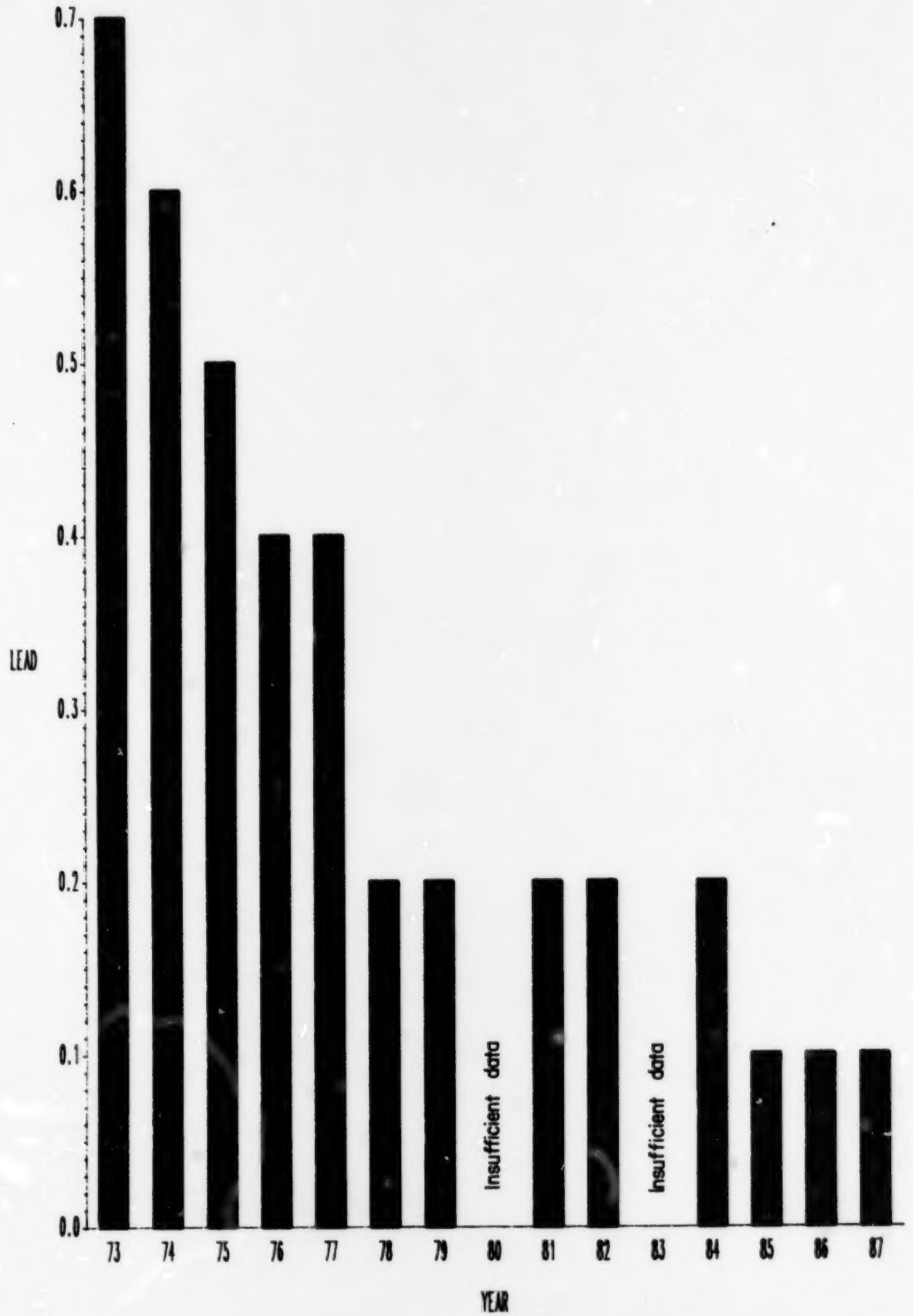

FIGURE 16. Average annual lead levels (ug/m^3) at station 63022, Thunder Bay, 1973-87 .

TABLE 1. Arsenic content (μg/g, dry weight) of trembling aspen foliage, Balmertown, 1983-87.

Site[a]	1983	1984	1985	1986	1987
1	5[b]	4	4	6	19
2	6	6	6	8	52
5	19	11	16	23	24
6	38	14	13	28	15
7	5	3	4	6	4
9[c]	4	7	6	6	7
11	4	3	13	4	11
12[c]	2	4	2	1	5
13	98	31	90	160	140
14	29	17	23	75	20
17	19	6	22	13	11
20[c]	3	14	5	2	11
21[c]	3	3	6	2	6
23	13	12	16	15	<1
24[c]	5	6	11	5	18
28	46	60	74	180	150
32	37	17	55	32	61
Controls	<1	<1	<1	<1	<1

[a] Shown in Figure 2.
[b] Values above guideline (2 μg/g) are underlined.
[c] Sites in townsite area.

TABLE 2. Average arsenic content (μg/g, dry weight) of foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1983-87.

Site	1983	1984	1985	1986	1987
Dickenson & Mine Rd.	18	8	12	26	18
Balmertown public school	7	4	6	4	14
Fifth St. & Mine Rd.	-	3	5	12	10
Control (Red Lake)	<1	<1	<1	<1	<1

TABLE 3. Average arsenic levels (μg/g, dry weight) in washed vegetables and surface soil (0-5 cm) from Balmertown gardens[a], 1983-87.

Sample	1983	1984	1985	1986	1987
	Balmertown				
Potato leaves[b]	8[c]	11	14	6	10
Potato tubers	1	<1	<1	<1	<1
Beet leaves	5	5	2	3	3
Beet roots	5	3	1	1	<1
Lettuce leaves	8	20	9	6	7
Garden soil	100	82	90	96	56
Lawn soil	330	230	180	230	190
	Red Lake				
Potato leaves[b]	2	1	1	2	<1
Potato tubers	<1	<1	<1	<1	<1
Beet leaves	<1	<1	<1	<1	<1
Beet roots	<1	<1	<1	<1	<1
Lettuce leaves	<1	<1	1	<1	<1
Garden soil	8	8	7	6	5
Lawn soil	15	10	9	8	8

[a] Three gardens in 1983, two gardens thereafter.
[b] Unwashed.
[c] Values above contaminant guidelines (2 μg/g for vegetation, 10 μg/g for soil) are underlined.

TABLE 4. Summary of sulphur dioxide data, Balmertown, 1983-87.

Year	Days of data	Annual ave. (ppm)	Annual exceedences		Growing season exceedences	
			Hours	Days	Hours	Days
1983	336	0.009	74	2	10	nil
1984	365	0.005	50	2	21	1
1985	341	0.010	114	3	61	2
1986	355	0.008	79	2	28	1
1987	332	0.010	87	7	23	1

TABLE 5. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1983-87.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1983	257	1.5	121	68
1984	327	1.1	187	28
1985	340	1.0	51	17
1986	352	1.0	77	12
1987	346	0.5	26	nil

TABLE 6. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980, 1984, 1987.

	Chloride(%, dry weight)			Sodium(μg/g, dry weight)		
Site[a]	1980	1984	1987	1980	1984	1987
1[b]	1.20	0.26	0.23	1800[d]	1200	390
2[b]	0.81	0.21	0.21	1400	970	290
3[b]	0.87	0.19	0.24	1200	530	230
4[b]	0.71	0.13	0.18	620	350	110
5	0.35	0.13	0.20	260	620	100
6	0.36	0.16	0.25	390	650	300
9	0.22	0.16	0.19	150	320	240
13	0.04	0.03	0.03	83	66	140
14[c]	0.08	0.08	0.16	53	270	180
16[c]	0.53	0.10	0.18	73	640	150
18	0.21	0.09	0.06	120	150	220
20	0.10	0.07	0.08	250	150	370
21	0.15	0.10	0.08	250	54	200
22	0.13	0.07	0.08	240	190	430
23	0.26	0.06	0.09	280	210	140
24	0.42	0.09	0.10	210	160	65
25	0.17	0.08	0.13	410	150	160
28		0.11	0.19		270	85
Controls	0.10	0.06	0.06	100	84	40

[a] See Figure 6 for site locations.

[b] Sites on company property.

[c] U.S. sites.

[d] Values above contaminant guideline (350 μg/g) for sodium in vegetation are underlined.

TABLE 7. Average annual dustfall ($g/m^2/30$ d), Fort Frances, 1987.

Monitoring sites[a]	Total dustfall	Insoluble dustfall	Saltcake in dustfall
62032	3.0	1.4	0.4
62033[b]	11.0[c]	4.6	3.2
62034	5.2	3.1	0.6
62035	7.9	4.0	1.6
62036	9.8	5.4	1.9
62037	3.1	1.5	0.6
62046[b]	10.5	5.3	2.1
62050	6.5	3.2	1.3
Averages	7.1	3.6	1.5
% of total dustfall		51	21

[a] See Figure 7.
[b] Sites on company property.
[c] Values above the maximum acceptable limit (4.6 $g/m^2/30$ d) are underlined.

TABLE 8. Average annual dustfall ($g/m^2/30$ d) at six Fort Frances monitoring sites[a], 1983-87. Percentages of total dustfall are shown in parentheses.

Parameter	1983	1984	1985	1986	1987
Total dustfall	7.5	9.0	9.4	9.1	7.1
Insoluble dustfall	4.1(55)	5.2(58)	5.1(54)	5.0(55)	3.6(51)
Saltcake in dustfall	1.2(16)	1.9(21)	1.2(13)	2.0(22)	1.5(21)

[a] Stations 62032, 62033, 62034, 62036, 62037 and 62046.

TABLE 9. Average annual sulphation rates (mg SO_3/100 cm^2/d), Fort Frances, 1983-87.

Station	Location	1983	1984	1985	1986	1987
62032	Cemetery	0.08	0.08	0.07	0.07	0.08
62033	Nelson/Portage	0.19	0.17	0.14	0.17	0.17
62034	First/Victoria	0.06	0.06	0.07	0.06	0.05
62035	Legion Building	0.11	0.10	0.11	0.10	0.09
62036	Sinclair/Victoria	0.06	0.06	0.08	0.06	0.07
62037	Reid/Gillon	0.05	<0.05	0.05	<0.05	<0.05
62046	Sinclair/Portage	0.09	0.13	0.10	0.10	0.09
62047	Eighth/Cornwall	0.11	0.12	0.13	0.11	0.09
62049	Sixth/Portage	0.06	<0.05	0.06	0.06	0.06
	AVERAGES	0.09	0.09	0.09	0.08	0.08

TABLE 10. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052 and 62032, Fort Frances, 1976–1987.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 62030/62052		
1976[a]	309	12.8	458	916
1977[a]	294	15.4	480	969
1978[a]	304	16.1	540	1035
1979[a]	344	10.2	353	911
1980[a]	352	9.3	499	872
1981[a]	277	12.0	279	806
1982[a]	320	8.8	543	685
1983[b]	336	4.9	254	418
1984[b]	332	2.8	98	135
1985[b]	363	2.0	191	87
1986[a,b]	335	3.9	226	300
1987[a]	359	5.5	278	431
		Station 62032		
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
1984	314	1.9	74	38
1985	363	1.1	61	28
1986	325	1.2	133	37
1987	345	1.8	215	61

[a] Station 62030
[b] Station 62052

TABLE 11. Average annual dustfall ($g/m^2/30$ d), Kenora 1983-87.

Station[a]	Location	1983	1984	1985	1986	1987
61003	Fourth/Main	2.5	4.8	5.4	3.3	3.2
61007	Melick/Ninth	7.0	10.9	9.7	8.9	7.5
61008	Melick/Eleventh	2.5	3.3	5.6	3.1	3.0
61009	Third/Matheson	3.3	4.5	5.1	3.2	3.7
	Averages	3.8	5.9	6.4	4.6	4.3

[a] See Figure 9.

[b] Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 12. Average annual sulphation rates (mg $SO_3/100\ cm^2/d$), Kenora, 1983-87.

Station[a]	Location	1983	1984	1985	1986	1987
61003	Fourth/Main	0.06	0.05	0.07	0.09	0.12
61007	Melick/Ninth	0.10	0.07	0.06	0.09	0.10
61008	Melick/Eleventh	0.20	0.11	0.09	0.08	0.06
61009	Third/Matheson	<0.05	<0.05	<0.05	<0.05	<0.05
	Averages	0.10	0.06	0.06	0.07	0.08

[a] See Figure 9.

TABLE 13. Average annual sulphation rates (mg SO_3/100 cm^2/d), Marathon, 1983-87.

Station	Location	1983	1984	1985	1986	1987
63027	McLeod/Abrams	0.19	0.16	0.13	0.18	0.15
63029	Marathon Shell	0.13	[a]	0.10	0.08	0.06
63030	Howe/Yawkey	0.12	0.10	0.08	0.07	0.05
63032	Heron Bay	0.06	0.04	0.06	0.05	<0.05
63033	Water Tower	0.21	0.14	0.13	0.19	0.10
	Averages	0.14		0.10	0.11	0.08

[a] Insufficient data to calculate average.

TABLE 14. Summary of TRS concentrations (ppb) at station 63034, Marathon, 1983-87.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1983	310	0.9	72	25
1984	329	1.0	71	22
1985	343	1.3	83	52
1986	316	2.1	131	115
1987	331	2.0	150	93

TABLE 15. Average annual dustfall (g/m^2/30 d), Red Rock, 1983-87.

Station[a]	Location	1983	1984	1985	1986	1987
63080[b]	Rankin Street	5.9[c]	9.0	6.8	5.9	6.2
63081	Stewart/Frost	4.3	5.9	4.5	4.4	4.8
63082	47 Timmins Street	6.0	7.0	4.9	4.6	5.2
63083	122 Brompton Road	2.0	2.1	3.0	2.6	2.8
	Averages	4.6	6.0	4.8	4.4	4.8

[a] See Figure 11.
[b] Site on company property.
[c] Values exceeding maximum acceptable limit of 4.6 are underlined.

TABLE 16. Summary of TRS concentrations (ppb) at station 63084, Red Rock, 1983-87.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1983	300	1.8	156	98
1984	365	1.3	111	23
1985	362	2.0	104	117
1986	317	1.9	80	87
1987	337	3.1	216	203

TABLE 17. Average annual sulphation rates (mg/SO_3/100 cm^2/d), Terrace Bay, 1983-87.

Station[a]	Location	1983	1984	1985	1986	1987
63090	St. Martin School	0.14	0.08	0.12	0.10	0.08
63091	Ft. Garry Road	0.14	0.08	0.14	0.10	0.07
63092	Terrace Heights Dr.	0.07	0.06	0.08	0.06	0.06
63093	Mill Road	0.08	0.09	0.13	0.09	0.11
63094	Highway 17, #1	0.14	0.13	0.13	0.08	0.08
63095	Highway 17, #2	0.08	0.06	0.08	0.06	0.07
63096	Highway 17, #3	0.06	0.06	0.04	<0.05	<0.05
	Averages	0.10	0.08	0.10	0.08	0.07

[a] See Figure 12.

TABLE 18. Summary of TRS concentrations (ppb) at station 63090, Terrace Bay, 1983-87.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1983	333	0.9	102	30
1984	331	1.2	104	38
1985	364	1.4	200	67
1986	350	1.5	155	72
1987	316	2.4	159	121

TABLE 19. Total dustfall ($g/m^2/30$ d), Thunder Bay, 1987.

Station[a]	Location	Monthly Min	Monthly Max	Annual average
63005	McKellar Hospital	1.1	5.7	2.9
63012	Dawson Court	1.0	5.2	2.3
63019	Main St. Pumping Station	0.8	<u>12.5</u>	3.4
63021	Mission Island	0.2	3.0	1.4
63022	St. Joseph's Hospital	1.4	4.8	2.9
63026	N. Cumberland Hydro	0.8	4.5	2.1
63046	Montreal Street	1.2	5.9	3.2
63047	Totem Trailer Court	2.1	<u>10.4</u>	<u>5.1</u>
63052	Thunder Bay Transit	1.4	7.0	2.0
63200	615 James St. South	0.7	3.8	2.0

[a] See Figure 13.
[b] Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 20. Total suspended particulate matter ($\mu g/m^3$), Thunder Bay, 1987.

Station[a]	Number of samples	Annual geometric mean	Number of samples above 120 $\mu g/m^3$	Maximum 24-hour value
63005	59	36	nil	87
63012	58	30	nil	119
63022	58	34	nil	89
63046	56	58	6	226[b]
63052	59	41	1	130
63200	56	32	nil	103

[a] See Figure 13.
[b] Values exceeding the maximum acceptable limit of 120 $\mu g/m^3$ (24-hour average) or 60 $\mu g/m^3$ (annual geometric mean) are underlined.

TABLE 21. Summary of carbon monoxide, nitrogen dioxide and ozone concentrations (ppm), station 63200, Thunder Bay, 1987.

	Maximum 1-hour average	Maximum 8-hour average	Maximum 24-hour average
Carbon monoxide	10.0	4.0	
Nitrogen dioxide	0.06		0.04
Ozone	0.062		

TABLE 22. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1987.

Station	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	0.001	0.09	0.02
63200	615 S. James Street	<0.001	0.02	<0.01
63041[a]	Mt. McKay		0.19	0.03
63042[a]	East End		0.10	<0.01
63044[a]	James St./Kam River		0.09	0.01
63048[a]	Ford Street		0.05	<0.01
63049[a]	Chippewa Park		0.04	0.01

[a]Ontario Hydro. 1987-88. Environmental Quality Compliance Reports, 1987. Technical and Training Services Division.

TABLE 23. Summary of total reduced sulphur concentrations (ppb), station 63046[a], Thunder Bay, 1977-1986.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1983	305	0.5	36	3
1984	164	0.6	22	nil
1985	286	0.8	27	nil
1986	337	1.0	55	4
1987	329	0.8	52	12

[a]See Figure 13 for station location.

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